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TMDL for Fecal Coliform Bacteria, Chlorides, Sulfates, Total Dissolved Solids, and Turbidity for Selected Subsegments in the Red River Basin, Louisiana

(100306, 100406, 100707, 100708, 100709, 100710, 100801, 100804, 100901, 101101, 101103, 101301, 101303, 101401)

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Prepared by:

Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for impaired waterbodies. A TMDL establishes the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant. TMDLs provide the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody and may include a future growth (FG) component. The TMDL components are illustrated using the following equation:

$$TMDL = \sum WLAs + \sum LAs + MOS + FG$$

The study area for this TMDL is the Red River Basin, which is in northwestern Louisiana. The Red River originates in eastern New Mexico and flows through portions of Texas, Oklahoma, and Arkansas before crossing the Louisiana state border. The river enters northwestern Louisiana and flows southward to Shreveport. The Red River joins the Atchafalaya River, which then flows to the Gulf of Mexico. Forest is the dominant land use in all but six of the listed subsegments in the Red River Basin. Most of the remaining subsegments have large areas of row crops, except two subsegments that have large urban areas.

Louisiana Department of Environmental Quality (LDEQ) included 23 subsegments in the Red River Basin on the state's 2004 section 303(d) list for various impairments. This TMDL report addresses 14 of the 23 listed subsegments (Table ES-1). Other reports cover the remaining nine subsegments. The impaired designated uses for the 14 subsegments are primary contact recreation, fish and wildlife propagation, and drinking water supply. The pollutants causing these impairments include fecal coliform bacteria, chloride, sulfate, total dissolved solids (TDS), and turbidity.

The numerical water quality criteria that apply to the impaired subsegments in the Red River Basin and that were used to calculate the total allowable loads are presented in Table ES-2.

Because turbidity cannot be expressed as a mass load, the turbidity TMDL was expressed using total suspended solids (TSS) as a surrogate for turbidity. Historical water quality data were analyzed for relationships between turbidity and TSS. A regression between turbidity and TSS was developed for subsegment 101401 using turbidity and TSS data from that subsegment, resulting in a surrogate TSS endpoint of 18 mg/L.

Table ES-1. Section 303(d) listing for stream reaches included in this report

Subseg. number	Subseg. name	Impaired use[a]	Causes of impairment: Chloride	Sulfate	TDS	Turbidity	Fecal coliforms	Suspected sources of impairment
100306	Kelly Bayou	PCR					X	Managed pasture grazing
100406	Flat River	PCR, FWP			X		X	Residential districts (TDS), managed pasture grazing (fecal coliforms)
100707	Castor Creek	PCR					X	Wildlife other than waterfowl
100708	Castor Creek tributary	FWP		X	X			Natural conditions—Water quality standards use attainability analyses needed
100709	Grand Bayou	PCR, FWP					X	Wildlife other than waterfowl
100710	Grand Bayou tributary	FWP	X	X	X			Municipal point source discharges
100801	Saline Bayou	PCR, FWP					X	Natural sources
100804	Saline Bayou tributary	FWP		X	X			Municipal point source discharges
100901	Bayou Nantaches	PCR, FWP					X	On-site treatment systems, package plant, or other permitted small-flow discharges
101101	Cane River	FWP, DWS	X		X			Natural conditions—Water quality standards use attainability analyses needed
101103	Bayou Kisatchie	PCR, FWP			X		X	Natural conditions—Water quality standards use attainability analyses needed (TDS), managed pasture grazing (fecal coliforms)
101301	Rigolette Bayou	PCR, FWP					X	Package plant or other permitted small flows discharges
101303	Iatt Creek	FWP			X			Natural conditions—Water quality standards use attainability analyses needed
101401	Buhlow Lake	FWP				X		Natural conditions—Water quality standards use attainability analyses needed

[a] PCR = primary contact recreation; FWP = fish and wildlife propagation; DWS = drinking water supply
Source: LDEQ 2005a.

The TMDLs for all pollutants (fecal coliform bacteria, turbidity, chloride, TDS, and sulfate) were developed using the load duration curve methodology. This method illustrates allowable loading at a wide range of streamflow conditions. The steps for applying this methodology were (1) developing a flow duration curve; (2) converting the flow duration curve to load duration curves; (3) plotting observed loads with load duration curves; (4) calculating the TMDL, MOS, FG, WLA, and LA; and (5) calculating percent reductions. Fecal coliform bacteria TMDLs were calculated seasonally on the basis of analyses of the applicable water quality criteria (i.e., calculating allowable loads and percent reductions for both summer and winter). The TMDLs for the other pollutants (chloride, sulfate, TDS, and turbidity) were not developed for a particular season and apply year-round.

Table ES-2. Numeric water quality criteria for the listed subsegments

Subsegment number	Subsegment name	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)	Turbidity (NTU)	Bacteria[a] (colonies/100 mL)
100306	Kelly Bayou					400 (5/01–10/31) 2,000 (11/01–4/30)
100406	Flat River			300		400 (5/01–10/31) 2,000 (11/01–4/30)
100707	Castor Creek					400 (5/01–10/31) 2,000 (11/01–4/30)
100708	Castor Creek tributary		9	79		
100709	Grand Bayou					400 (5/01–10/31) 2,000 (11/01–4/30)
100710	Grand Bayou tributary	26	9	79		
100801	Saline Bayou					400 (5/01–10/31) 2,000 (11/01–4/30)
100804	Saline Bayou tributary		20	250		
100901	Bayou Nantaches					400 (5/01–10/31) 2,000 (11/01–4/30)
101101	Cane River	25		100		
101103	Bayou Kisatchie			100		400 (5/01–10/31) 2,000 (11/01–4/30)
101301	Rigolette Bayou					400 (5/01–10/31) 2,000 (11/01–4/30)
101303	Iatt Creek			100		
101401	Buhlow Lake				25	

[a] Criteria for primary and secondary contact recreation apply. Primary contact recreation: No more than 25 percent of the total samples collected on a monthly basis shall exceed a fecal coliform bacteria density of 400/100 mL. This shall apply only during the defined recreational period of 5/01 through 10/31. For all other periods, a fecal coliform bacteria density of 2,000/100 mL for secondary contact recreation applies.
Source: LDEQ 2005b

In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide the basis for establishing water quality-based controls. WLAs were given to permitted point source discharges, including Phase I and Phase II municipal separate storm sewer systems (MS4s). The LAs include background loadings as well as human-induced nonpoint sources. An explicit MOS of 10 percent and was included, except for turbidity, sediment, and TSS which had an implicit MOS. A FG component of 10 percent is also included in this TMDL.

None of the subsegments requires fecal coliform bacteria reductions in the winter months, and the summer month reductions range from 0 to 78 percent. The chloride-impaired subsegments require reductions of 52 and 59 percent. The reductions for sulfate range from 0 to 86 percent. TDS reductions range from 44 to 77 percent, and the reduction for the one subsegment impaired by turbidity is 43 percent. Summaries of the TMDLs for the subsegments addressed in this report are presented in Tables ES-3 through ES-5.

Hurricane Katrina made landfall on Monday, August 29, 2005, as a Category 4 hurricane. The storm brought heavy winds and rain to southeast Louisiana, breaching several levees and flooding up to 80 percent of New Orleans and large areas of coastal Louisiana. Much of the area that was flooded during Hurricane Katrina was flooded again by the storm surge from Hurricane Rita. Both Hurricanes Katrina and Rita have caused a significant amount of change in

Table ES-3. Summary of fecal coliform bacteria TMDLs, MOS, FG, WLAs, and LAs for Red River Basin

Subsegment	Station	Season	Percent reduction	Total allowable load	Explicit MOS (10%)	Future growth (10%)	∑ WLA	∑ LA
				1×10^9 colonies/day				
100306	56	Summer	54.4	21.76	2.18	0.00	12.99	6.59
100306	56	Winter	0.0	372.30	37.23	0.00	222.32	112.75
100406	272	Summer	48.6	62.32	6.23	6.23	5.90	43.95
100406	272	Winter	0.0	602.60	60.26	60.26	5.90	476.18
100707	1189	Summer	55.0	17.52	1.75	0.00	1.75	14.02
100707	1189	Winter	0.0	291.16	29.12	0.00	29.12	232.93
100709	1190	Summer	28.0	64.88	6.49	6.49	0.79	51.11
100709	1190	Winter	0.0	1,083.34	108.33	108.33	0.79	865.89
100801	75	Summer	0.0	144.65	14.47	14.47	0.86	114.86
100801	75	Winter	0.0	2,415.52	241.55	241.55	0.86	1,931.55
100901	1215	Summer	77.5	56.33	5.63	5.63	0.76	44.30
100901	1215	Winter	0.0	632.08	63.21	63.21	0.76	504.91
101103	1218	Summer	77.5	205.84	20.58	0.00	20.58	164.67
101103	1218	Winter	0.0	2,991.37	299.14	0.00	299.14	2,393.09
101301	1220	Summer	0.0	129.85	12.98	12.98	5.21	98.67
101301	1220	Winter	0.0	1,457.13	145.71	145.71	16.78	1,148.93

Table ES-4. Summary of chloride and sulfate TMDLs, MOS, FG, WLAs, and LAs for Red River Basin

Subsegment	Station	Pollutant	Percent reduction	Total allowable load	Explicit MOS (10%)	Future growth (10%)	∑ WLA	∑ LA
				kg/day				
100710	1195	Chloride	59.2	10.24	1.02	1.02	4.92	3.27
101101	1217	Chloride	51.9	2,374.26	237.43	237.43	118.47	1,780.94
100708	1194	Sulfate	54.5	10.88	1.09	1.09	5.68	3.03
100710	1195	Sulfate	85.9	3.54	0.35	0.35	1.70	1.13
100804	1206	Sulfate	0.0	51.33	5.13	5.13	37.85	3.21

Table ES-5. Summary of TDS and TSS TMDLs, MOS, FG, WLAs, and LAs for Red River Basin

Subsegment	Station	Pollutant	Percent reduction	Total allowable loading	Explicit MOS (10%)	Future growth (10%)	∑ WLA	∑ LA
				ton/day				
100406	389	TDS	48.7	9.70	0.97	0.97	1.35	6.41
100708	1194	TDS	43.6	0.09	0.01	0.01	0.02	0.05
100710	1195	TDS	65.3	0.03	0.00	0.00	0.02	0.01
100804	1206	TDS	51.9	0.71	0.07	0.07	0.52	0.04
101101	1217	TDS	76.6	10.47	1.05	1.05	0.77	7.61
101103	42	TDS	76.7	11.34	1.13	1.13	0.00	9.08
101303	1222	TDS	63.4	4.36	0.44	0.44	0.00	3.49
101401	1223	Tur/TSS	43.3	0.04	Implicit	0.00	0.02	0.01

sedimentation and water quality in southern Louisiana. Many wastewater treatment facilities were temporarily or permanently damaged. Some wastewater treatment facilities will be rebuilt while others will be relocated. The hurricanes expedited the loss of coastal land and modified the hydrology of some of the coastal waterbodies. Several federal and state agencies including the EPA and LDEQ are engaged in collecting environmental data and assessing the recovery of the Gulf of Mexico waters. The proposed TMDLs in this report were developed on the basis of pre-hurricane conditions. Therefore, post-hurricane conditions and other factors could delay the implementation of these proposed TMDLs, render some proposed TMDLs obsolete, or could require modifications of the TMDLs.

Much of coastal Louisiana was built by the process of delta formation through flooding and deposition of sediments by the rise and fall of the Mississippi River. According to EPA's present knowledge, extensive areas of wetlands and coastal marshes are affected by a high rate of subsidence and degradation, primarily due to a lack of historical sediment and nutrients entering the wetlands. Subsidence is a natural process, but the building of levee systems has restricted the Mississippi River's course and, therefore, is preventing the natural cycle of the river and the natural process of delta formation. According to EPA, a large portion of the state's coastal wetlands have undergone and continue to undergo severe deprivation of sediments and nutrients that has led to the breakup of the natural system. In addition, EPA believes that many of Louisiana's wetlands have become isolated from the riverine sources that created them and are becoming stagnant and starved for nutrients and organic and inorganic sediments. Note that restoring these eroding wetlands involves supplying nutrients to these areas through managed Mississippi River diversions.

According to EPA's understanding, if any future diversion from the Mississippi River or other tributaries will increase flow, the nonpoint source load allocation and TMDLs will also be increased proportionately. From EPA's current understanding, the diversion projects are supported by both state and federal agencies, including EPA and the U.S. Army Corps of Engineers (USACE). The diversions are managed by the USACE and the state, and the projects include post-diversion monitoring to determine effectiveness of the project and to monitor water quality conditions.

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1 INTRODUCTION

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (Title 40 of the *Code of Federal Regulations* [CFR] Part 130) requires states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not supporting their designated uses, even if pollutant sources have implemented technology-based controls. A TMDL establishes the maximum allowable load (mass per unit of time) of a pollutant that a waterbody is able to assimilate and still support its designated uses. The maximum allowable load is determined on the basis of the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

Monitoring data collected by the Louisiana Department of Environmental Quality (LDEQ) indicate that observed pollutant levels sometimes exceed water quality criteria for 23 subsegments in the Red River Basin. The TMDL report, for this task order, addresses 14 of the 23 listed subsegments. Other reports cover the remaining nine subsegments. The impaired designated uses for the 14 subsegments are primary contact recreation, fish and wildlife propagation, and drinking water supply. The pollutants causing these impairments include fecal coliform bacteria, chloride, sulfate, total dissolved solids (TDS), and turbidity. Table 1-1 presents information from Louisiana's 2004 section 303(d) list for the 14 subsegments.

Table 1-1. Subsegments and parameters for impairments addressed in this report

Subseg. number	Subseg. name	Impaired use[a]	Causes of impairment					Suspected sources of impairment
			Chloride	Sulfate	TDS	Turbidity	Fecal coliforms	
100306	Kelly Bayou	PCR					X	Managed pasture grazing
100406	Flat River	PCR, FWP			X		X	Residential districts (TDS), managed pasture grazing (fecal coliform bacteria)
100707	Castor Creek	PCR					X	Wildlife other than waterfowl
100708	Castor Creek tributary	FWP		X	X			Natural conditions—Water quality standards use attainability analyses needed
100709	Grand Bayou	PCR, FWP					X	Wildlife other than waterfowl
100710	Grand Bayou tributary	FWP	X	X	X			Municipal point source discharges
100801	Saline Bayou	PCR, FWP					X	Natural sources
100804	Saline Bayou tributary	FWP		X	X			Municipal point source discharges
100901	Bayou Nantaches	PCR, FWP					X	On-site treatment systems, package plant, or other permitted small-flow discharges
101101	Cane River	FWP, DWS	X		X			Natural conditions—Water quality standards use attainability analyses needed
101103	Bayou Kisatchie	PCR, FWP			X		X	Natural conditions—Water quality standards use attainability analyses needed (TDS), managed pasture grazing (fecal coliform bacteria)

Table 1-1. (continued)

Subseg. number	Subseg. name	Impaired use[a]	Causes of impairment: Chloride	Sulfate	TDS	Turbidity	Fecal coliforms	Suspected sources of impairment
101301	Rigolette Bayou	PCR, FWP					X	Package plant or other permitted small flows discharges
101303	Iatt Creek	FWP			X			Natural conditions—Water quality standards use attainability analyses needed
101401	Buhlow Lake	FWP				X		Natural conditions—Water quality standards use attainability analyses needed

[a] PCR = primary contact recreation; FWP = fish and wildlife propagation; DWS = drinking water supply
Source: LDEQ 2005a.

2 BACKGROUND INFORMATION

2.1 General Description

The 14 subsegments addressed in this TMDL report are in northwestern Louisiana (Figure 2-1) in portions of U.S. Geological Survey (USGS) hydrologic unit codes (HUCs) 11140204, 11140207, 11140208, 11140209, and 11140304. The subsegments are in portions of 10 parishes. All the subsegments flow to the Red River, which flows through central Louisiana. The Red River originates in eastern New Mexico and flows through portions of Texas, Oklahoma, and Arkansas before crossing the Louisiana state border. The river enters northwestern Louisiana and flows southward to Shreveport. The Red River joins the Atchafalaya River, which then flows to the Gulf of Mexico. The portion of the river from the Arkansas state line to the city of Alexandria, Louisiana, which is the portion addressed in this report, is characterized by high banks that range from 20 to 35 feet above low water level. Table 2-1 lists the parishes in which the subsegments are located and the approximate drainage area of each subsegment.

Table 2-1. Parish and drainage area for each listed subsegment in the Red River Basin

Subsegment number	Subsegment name	Parish	Drainage area (acres)
100306	Kelly Bayou	Caddo	2,950.1
100406	Flat River	Bossier, Red River	6,980.6
100707	Castor Creek	Bienville	2,175.6
100708	Unnamed Tributary to Castor Creek	Bienville	229.1
100709	Grand Bayou	Bienville, Red River	8,054.1
100710	Unnamed Tributary to Grand Bayou	Red River	45.9
100801	Saline Bayou	Bienville, Winn	17,958.1
100804	Unnamed Tributary to Saline Bayou	Bienville	151.6
100901	Bayou Nantaches	Grant, Winn	4,439.0
101101	Cane River	Natchitoches, Rapides	19,981.4
101103	Bayou Kisatchie	Natchitoches, Sabine, Vernon	21,652.1
101301	Rigolette Bayou	Grant, Natchitoches, Rapides	10,233.8
101303	Iatt Creek	Grant, Winn	10,134.1
101401	Buhlow Lake	Rapides	290.3

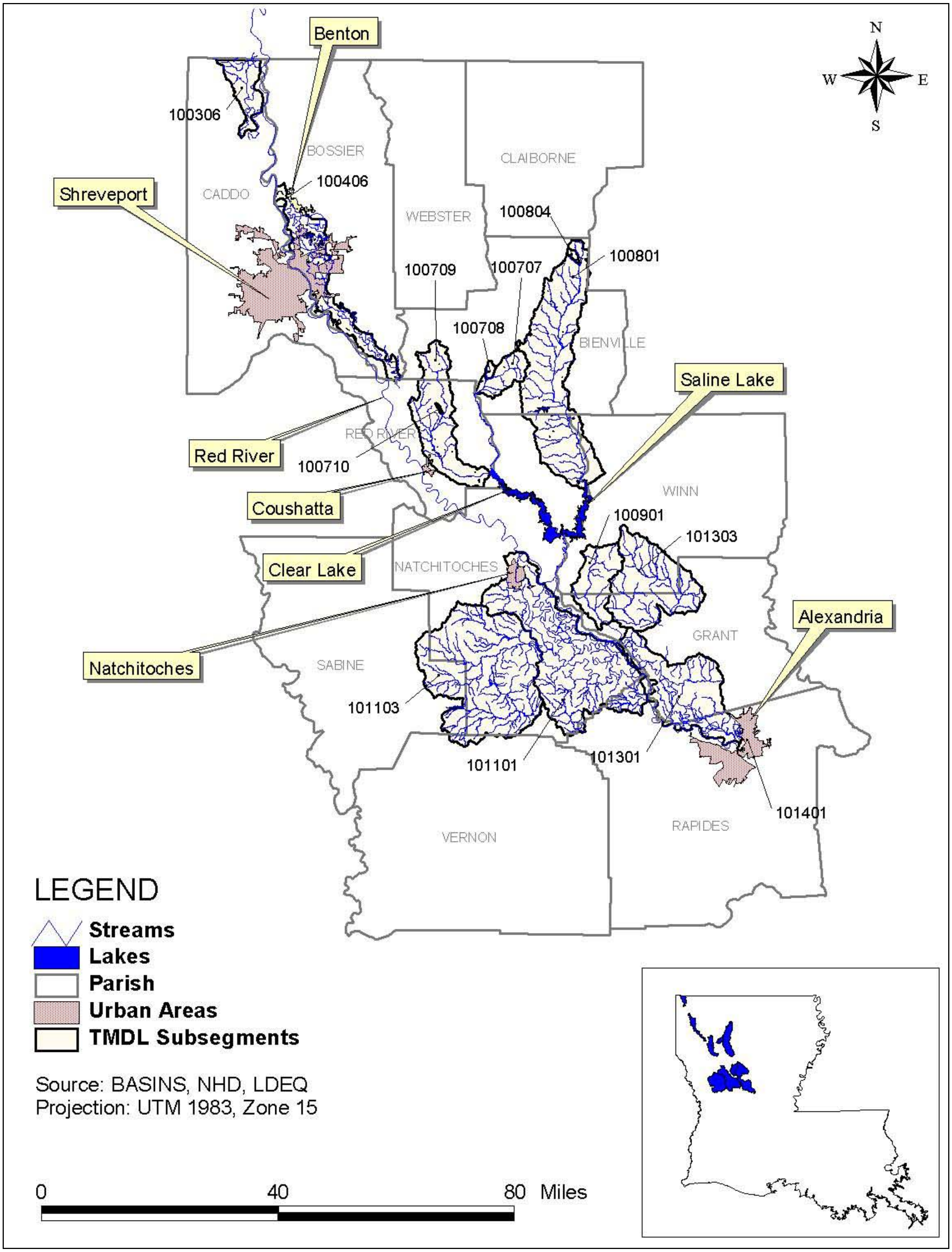

Figure 2-1. Location of Red River Basin subsegments.

2.2 Land Use

Land use data were obtained from the USGS National Land Cover Data set (NLCD). The NLCD data are based on satellite imagery from the early 1990s. Forest is the dominant land use in all but six of the listed subsegments in the Red River Basin. Most of the remaining subsegments have large areas of row crops except subsegments 100804 (Saline Bayou) and 101401 (Buhlow Lake), which have large urban areas. All other subsegments have only a small percentage of urban area; subsegment 100406 has the largest urban area at 12 percent. Table 2-2 and Figure 2-2 present the percentage of subsegment area covered by each land use and the land use coverage, respectively.

Table 2-2. Percent land use per subsegment

Land use	Percent coverage by subsegment number						
	100306	**100406**	**100707**	**100708**	**100709**	**100710**	**100801**
Water	0.4	0.8	0.4	0.5	0.8	0.5	1.3
Urban	0.4	12.3	0.2	2.4	0.2	0.1	0.3
Barren	0.8	0.1	5.1	0.0	1.4	0.2	3.5
Forest	37.0	11.8	83.2	81.7	65.3	55.5	81.4
Grasslands/herbaceous	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pasture/hay	18.1	17.1	2.4	4.7	12.2	21.0	2.3
Row crops	39.5	43.8	1.9	3.0	10.2	19.9	1.5
Small grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban/recreational grasses	0.0	3.1	0.0	0.0	0.0	0.0	0.0
Wetlands	3.8	10.9	6.8	7.6	9.9	3.1	9.8
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Land use	**Percent coverage by subsegment number**						
	100804	**100901**	**101101**	**101301**	**101103**	**101303**	**101401**
Water	2.0	0.4	1.8	1.2	0.5	0.2	8.5
Urban	44.0	0.4	2.2	2.6	0.2	0.3	38.5
Barren	0.1	3.3	1.1	0.5	3.7	2.9	0.1
Forest	28.4	80.6	40.2	47.6	83.2	86.6	42.1
Grasslands/herbaceous	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pasture/hay	13.6	3.6	7.7	7.2	1.5	1.7	1.4
Row crops	6.7	4.6	39.3	26.5	0.9	1.1	1.0
Small grains	0.0	0.0	1.2	1.1	0.0	0.0	0.0
Urban/recreational grasses	3.7	0.0	0.6	0.2	0.0	0.1	6.9
Wetlands	1.5	7.2	5.8	13.0	9.9	7.2	1.5
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

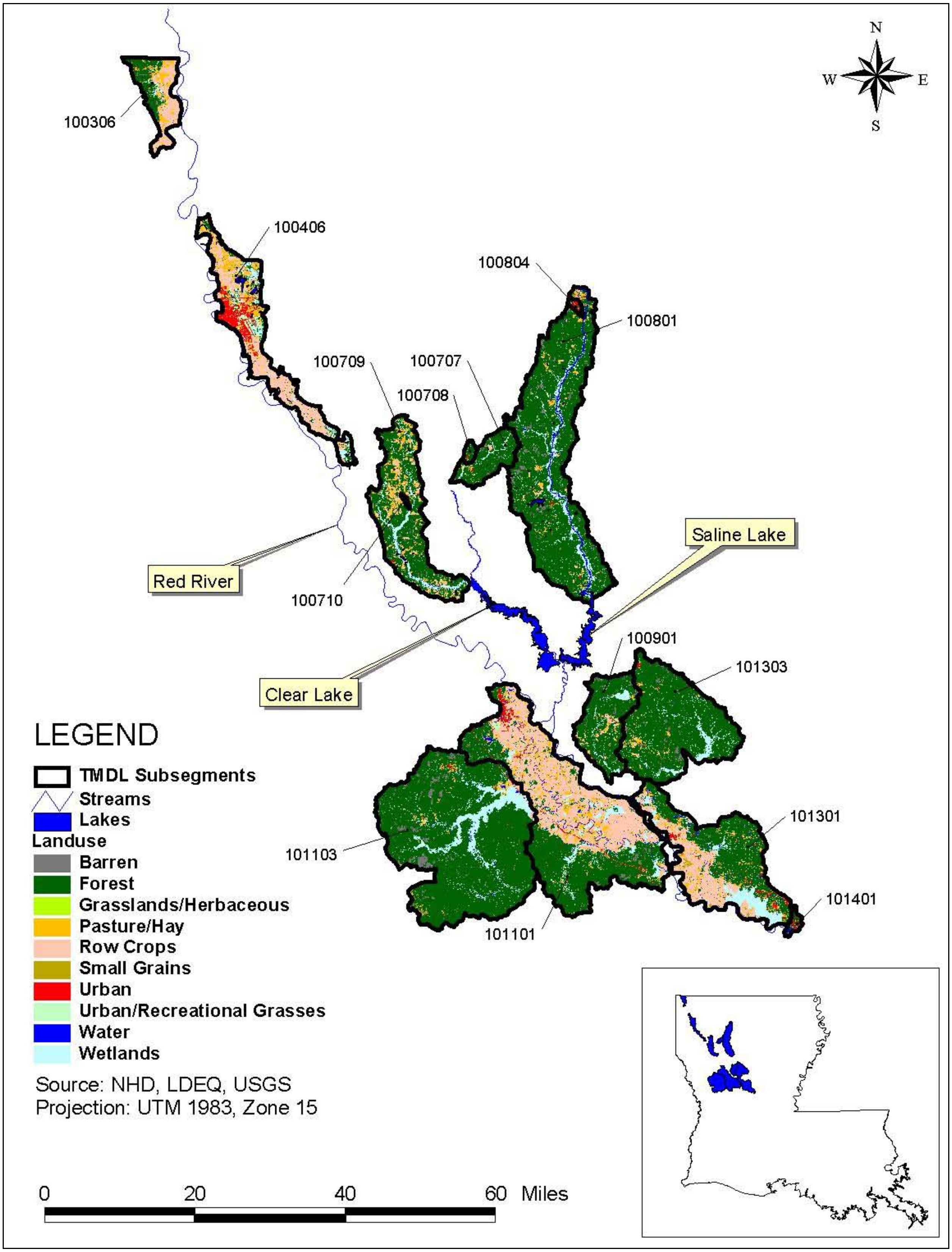

Figure 2-2. Land use in the Red River Basin subsegments.

2.3 Soils

General soils data for the United States are provided as part of the Natural Resources Conservation Service's (NRCS) State Soil Geographic (STATSGO) database. Soils data from this database and a geographic information system (GIS) coverage from NRCS were used to characterize soils in the Red River Basin subsegments.

One of the soil characteristics provided in the STATSGO database is the K-factor. The K-factor is a component of the Universal Soil Loss Equation, or USLE (Wischmeier and Smith 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion, and values can range from 0 to 1.00. In practice, maximum factor values generally do not exceed 0.67. Large K-factor values reflect greater inherent soil erodibility. The distribution of K-factor values in the surface soil layers of the Red River Basin subsegments is shown in Figure 2-3 and Table 2-3. The figure indicates that, on average, the soils in the basin have K-factors that range from 0.181 to 0.485, suggesting a wide range of soil erosion potential. Erosion is influenced by a number of other factors, including rainfall and runoff, land slope, vegetation cover, and land management practices.

The hydrologic soil group classification is another commonly used soil characteristic provided in the STATSGO database. The hydrologic soil group is a means for grouping soils by similar infiltration and runoff characteristics. Clay soils that are poorly drained tend to have the lowest infiltration rates, whereas sandy soils that are well-drained have the highest infiltration rates. NRCS has defined four hydrologic groups for soils (Table 2-4). The STATSGO data were summarized using the major hydrologic group in the soil surface layers (Figure 2-4).

The northernmost subsegments (100306 and 100406) are made up mostly of soil types in the C hydrologic group (85 percent) with small portions of A and D. This suggests that these subsegments are dominated by slow infiltration rates and fine-textured soils.

The subsegments in the middle of the Red River Basin (100804, 100708, 100710, 100801, 100707, and 100709) are a mixture of the B, C, and D hydrologic soil groups. There are no A soils in this section of the basin. Grand Bayou (100709), Castor Creek (100707), and the unnamed tributaries in each of those subsegments (100710 and 100708, respectively) contain mostly B soils, while Saline Bayou (100801) and its unnamed tributary (100804) are composed of mostly C soils.

Subsegments 101103 (Kisatchie Bayou) and 101101 (Cane River) are a mix of C and D soils with very small portions of A and B, meaning that these subsegments typically have slow drainage.

Subsegments 100901 (Bayou Nantaches), 101303 (Iatt Creek), and 101301(Rigolette Bayou) are a mixture of B, C, and D soils. There are no A soils in these subsegments. The small subsegment 101401 (Lake Buhlow) is entirely B soils, which are moderately well-drained soils.

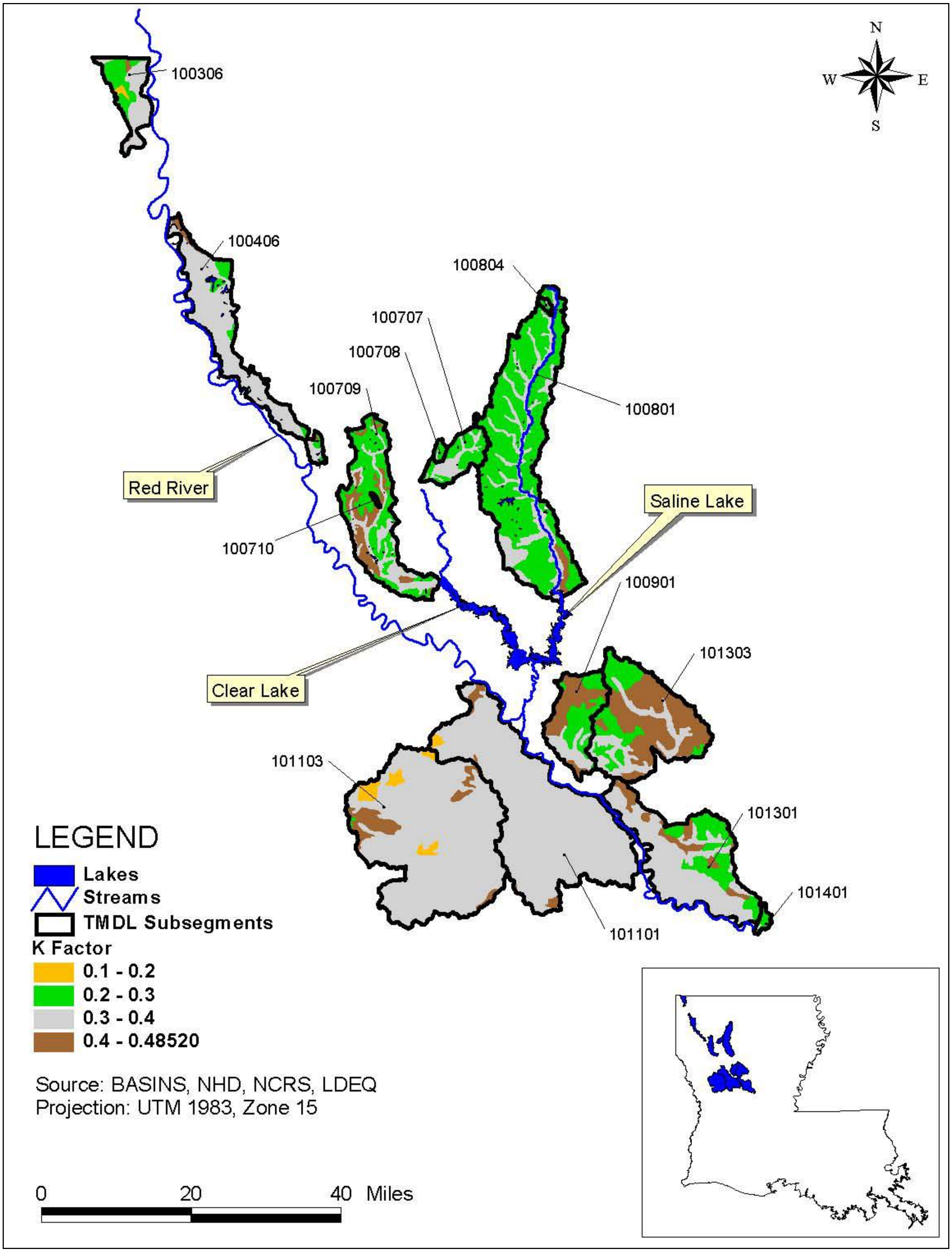

Figure 2-3. Soil K-factors in the Red River Basin subsegments.

Table 2-3. Soil Properties

Subsegment	K-Factor range	Surface texture	Hydrologic soil group
100306	0.1807–0.4611	silt loam, very fine sandy loam, silty clay, variable, fine sandy loam, loamy fine sand, clay, silty clay loam, gravelly fine sandy loam, loam	A, C, D
100406	0.2996–0.4698	silt loam, very fine sandy loam, silty clay, variable, fine sandy loam, clay, silty clay loam	C, D
100707	0.2016–0.3544	silt loam, very fine sandy loam, silty clay, variable, fine sandy loam, loamy fine sandy, clay, gravelly fine sandy loam, sandy loam, gravelly loamy fine sand, sandy clay loam	B, C
100708	0.2016–0.3544	silt loam, fine sandy loam, very fine sandy loam, clay, loamy fine sand, sandy loam, variable	B, C
100709	0.2651–0.4852	silt loam, fine sandy loam, very fine sandy loam, clay, loamy fine sand, sandy loam, variable, loam, silty clay loam	B, C, D
100710	0.2651–0.4346	silt loam, fine sandy loam, very fine sandy loam, loamy fine sand, variable	B, D
100801	0.2016–0.4503	silt loam, fine sandy loam, very fine sandy loam, clay, loamy fine sand, variable, loamy sand, unweathered bedrock, gravelly loamy fine sand, gravelly fine sandy loam, silty clay, sandy clay loam	B, C, D
100804	0.2469–0.3511	silt loam, fine sandy loam, very fine sandy loam, clay, loamy fine sand, sandy loam, variable, gravelly loamy fine sand, gravelly fine sandy loam	C
100901	0.2701–0.4749	silt loam, fine sandy loam, very fine sandy loam, clay, loamy fine sand, variable, loam, silty clay loam, unweathered bedrock	B, C, D
101101	0.1880–0.4588	silt loam, fine sandy loam, very fine sandy loam, loamy sand, loamy fine sand, sand, loam, silty clay loam, sandy clay loam, clay, silty clay, silty clay loam, silty loam	A, B, C, D
101103	0.1880–0.4596	silt loam, fine sandy loam, very fine sandy loam, loamy sand, loamy fine sand, sand, loam, silty clay loam, sandy clay loam, clay, silty clay, silty clay loam, gravelly fine sandy loam, clay loam	A, B, C, D
101301	0.2701–0.4815	silt loam, fine sandy loam, very fine sandy loam, loamy fine sand, clay, silty clay, silty clay loam, variable	B, C, D
101303	0.2701–0.4749	silt loam, fine sandy loam, very fine sandy loam, loamy fine sand, sand, loam, silty clay loam, clay, silty clay loam, variable, unweathered bedrock	B, C, D
101401	0.2701–0.3953	silt loam, fine sandy loam, very fine sandy loam, loamy fine sand, clay, silty clay loam, variable	B

Table 2-4. Hydrologic soil groups

Hydrologic soil group	Description
A	Soils with high infiltration rates. Usually deep, well-drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well-drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.

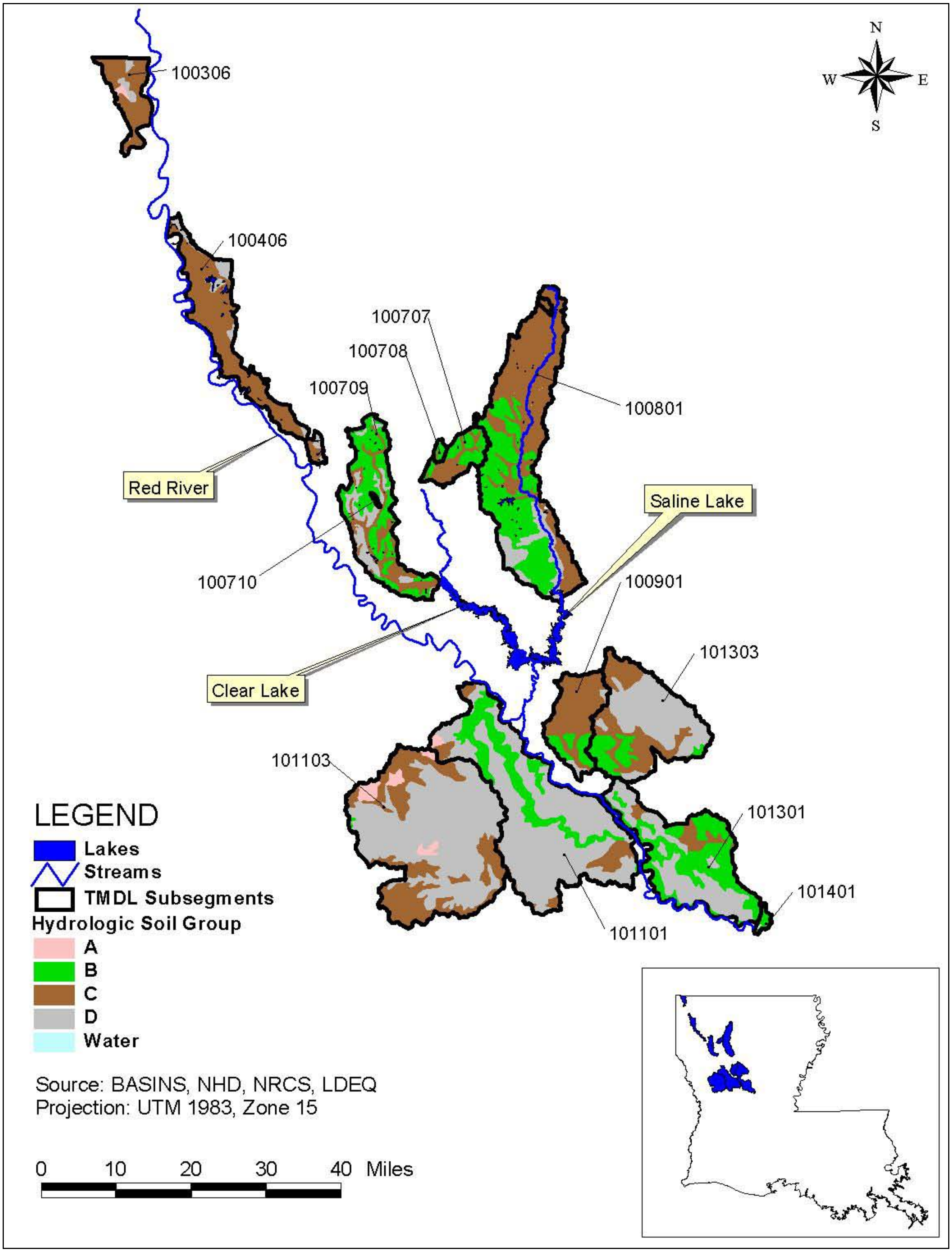

Figure 2-4. Hydrologic soil groups in the Red River Basin subsegments.

2.4 Flow Characteristics

Because there is only one active USGS flow monitoring gage in any of the listed subsegments, flow data are not available for all the subsegments in the Red River Basin. Table 2-5 presents information for the flow gage in the listed subsegments and four nearby flow gages.

Table 2-5. USGS flow gage information for the Red River Basin

Station number	Station name	Period of record	Drainage area (square miles)
07348700	Bayou Dorcheat near Springhill, LA	10/1/1957–9/30/2003	605
07349860	Red Chute Bayou at Sligo, LA	7/10/1980–9/30/2003	980
07352000	Saline Bayou near Lucky, LA	10/1/1940–9/30/2003	154
07373000	Big Creek at Pollack, LA	1/1/1942–9/30/2002	51
08025500	Bayou Toro near Toro, LA	10/1/1955–9/30/2002	148

USGS gage 07348700 is approximately 25 miles east of subsegment 100306 (Kelly Bayou). USGS gage 07349860 is less than 2 miles east of the center of subsegment 100406 (Flat River) in the adjacent watershed. USGS gage 07352000 is in subsegment 100801 (Saline Bayou), approximately 20 miles downstream of subsegment 100804 (unnamed tributary to Saline Bayou). The gage is also approximately 4 miles east of 100707 (Castor Creek), which is adjacent to Saline Bayou, and about 18 miles east of 100709 (Grand Bayou) and 100710 (unnamed tributary to Grand Bayou). USGS gage 07373000 is about 30 miles southeast of subsegment 100901 (Bayou Nantaches), 10 miles east of subsegment 101301 (Rigolette Bayou), 21 miles southeast of subsegment 101303 (Iatt Creek), and 13 miles north of subsegment 101401 (Buhlow Creek). Finally, USGS gage 0802550 is on Bayou Toro approximately 15 miles southwest of subsegment 101103 (Kisatchie Bayou) and about 30 miles southwest of subsegment 101101 (Cane Creek). The locations of the five USGS gages are shown in Figure 2-5.

The seasonal distribution of flow at each of the five gaging stations is shown in Figures 2-6 through 2-10. Low flow occurs in the summer and early fall, and high flow tends to occur in late winter and early spring.

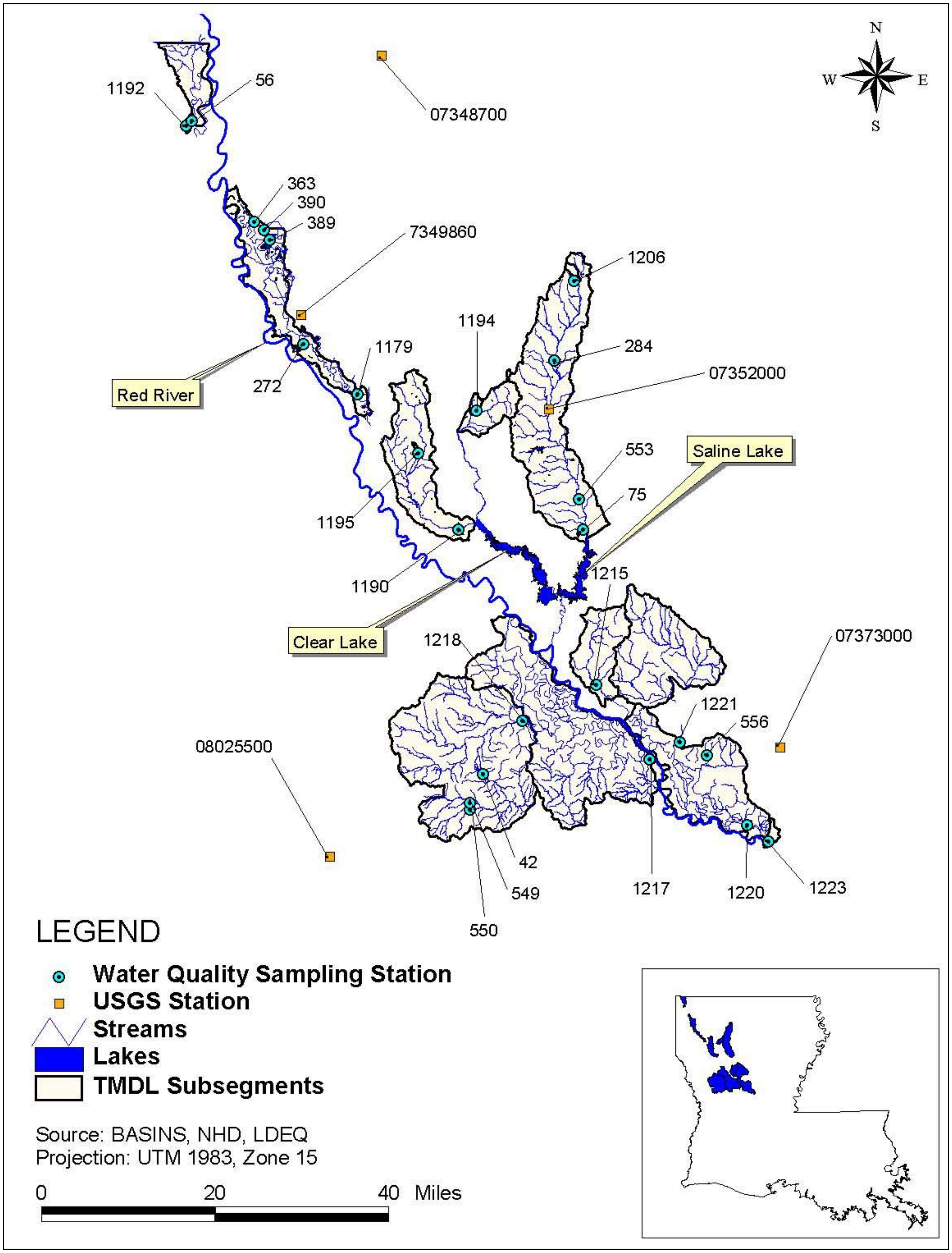

Figure 2-5. Location of USGS gages and water quality sampling stations assigned to the subsegments in the Red River Basin.

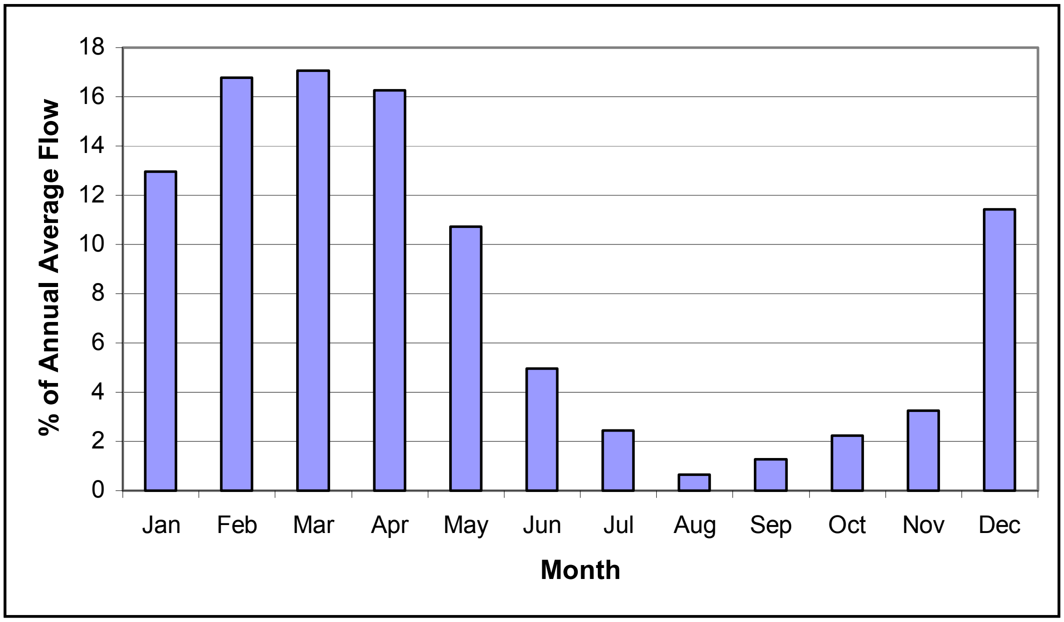

Figure 2-6. Seasonal distribution of flow at Bayou Dorcheat near Springhill, Louisiana (USGS 07348700) for 1958 through 2002.

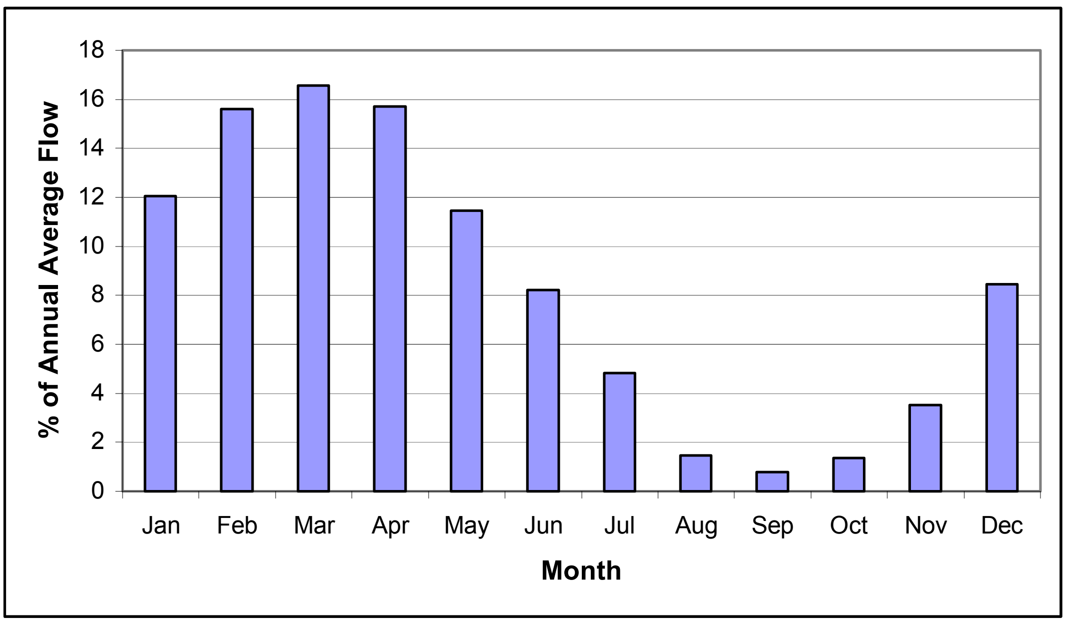

Figure 2-7. Seasonal distribution of flow at Red Chute Bayou at Sligo, Louisiana (USGS 07349860) for 1981 through 2002.

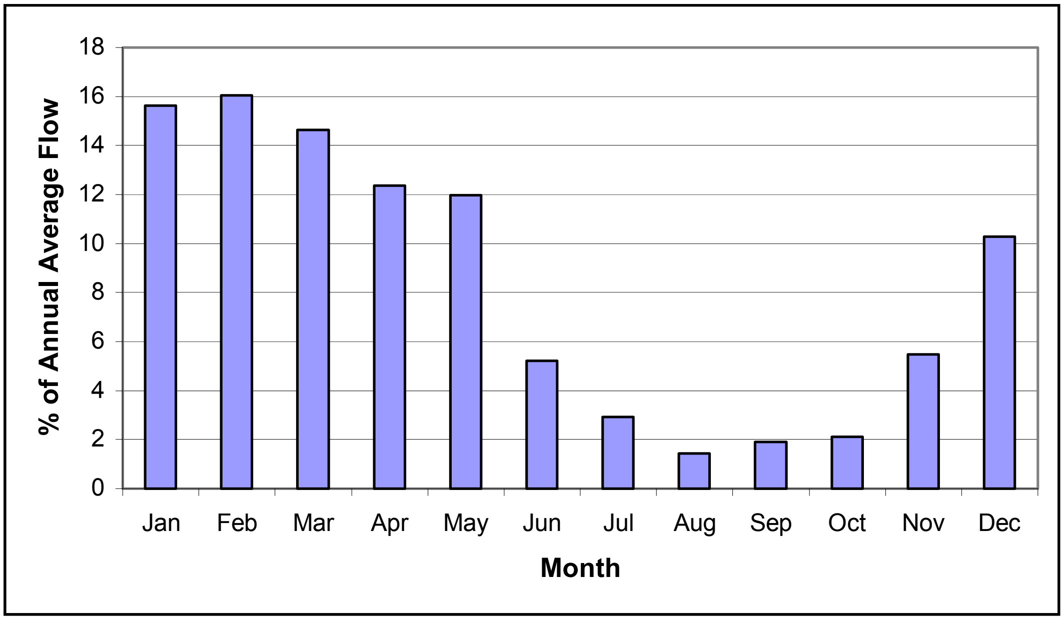

Figure 2-8. Seasonal distribution of flow at Saline Bayou near Lucky, Louisiana (USGS 07352000) for 1941 through 2002.

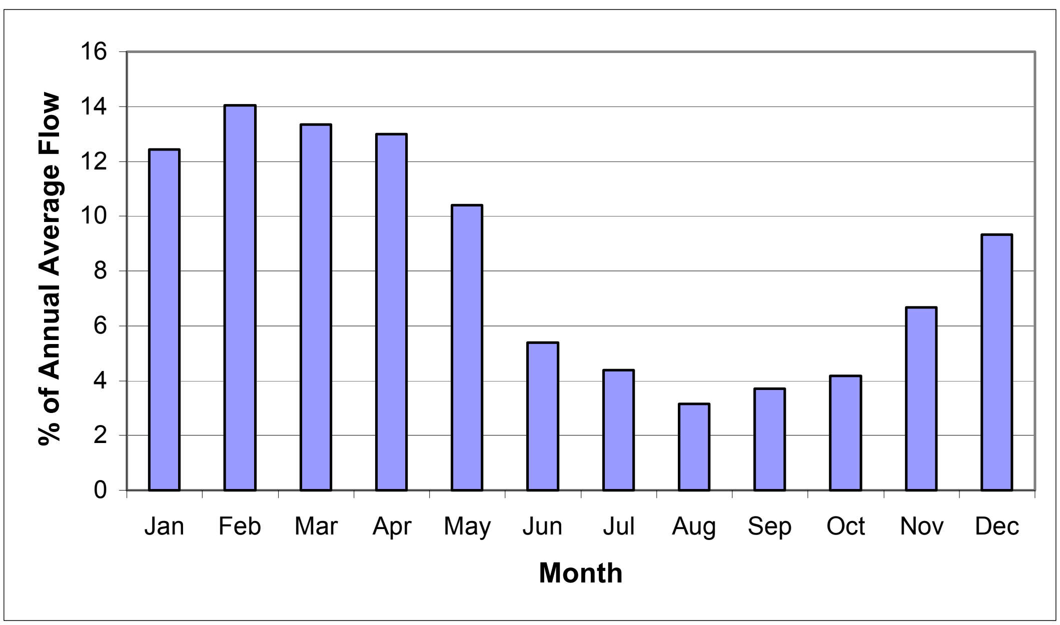

Figure 2-9. Seasonal distribution of flow at Big Creek at Pollack, Louisiana (USGS 07373000) for 1942 through 2001.

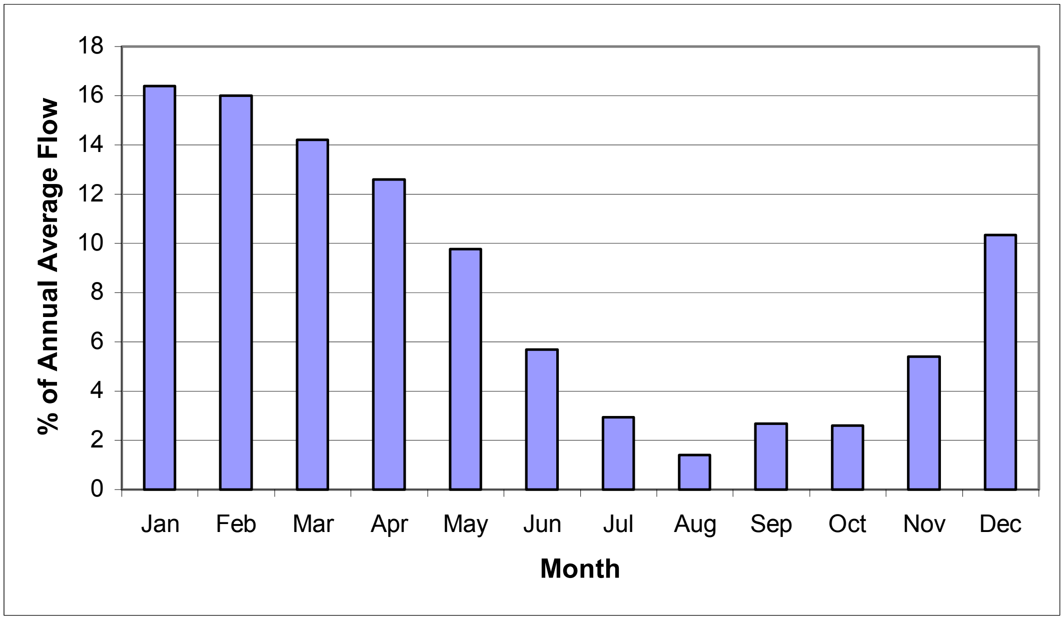

Figure 2-10. Seasonal distribution of flow at Bayou Toro near Toro, Louisiana (USGS 08025500) for 1956 through 2001.

2.5 Designated Uses and Water Quality Criteria

The state of Louisiana's 2004 section 303(d) list indicates that the 14 listed subsegments have varied use designations, which include primary contact recreation, fish and wildlife propagation, and drinking water supply. The designated uses and water quality criteria for each of the listed pollutants are discussed below. Water quality criteria for these subsegments are presented in Table 2-6; the designated uses were presented in Table 1-1.

The numeric criteria in Table 2-6 were used in conjunction with the assessment methodology presented in LDEQ's 305(b) report (LDEQ 2002b). LDEQ's assessment methodology specifies that the fish and wildlife use must be fully supported with no more than 30 percent of values exceeding the criteria for chloride, sulfate, and TDS. For fecal coliform bacteria, the primary contact recreation and secondary contact recreation uses are to be fully supported with no more than 25 percent of the values exceeding the criteria.

Fecal Coliform Bacteria

For the eight subsegments listed for impairments due to fecal coliform bacteria, the impaired designated use is primary contact recreation. Primary contact recreation involves any recreational or other water contact use involving full-body exposure to water and considerable probability of ingesting water. Examples are swimming and water skiing. Secondary contact recreation involves activities like fishing, wading, or boating, where water contact is accidental or incidental and there is only a minimal chance of ingesting appreciable amounts of water.

Table 2-6. Numeric criteria for the subsegments of concern in the Red River Basin

Subsegment number	Subsegment name	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)	Turbidity (NTU)	Bacteria[a] (colonies/100 mL)
100306	Kelly Bayou					400 (5/01–10/31) 2,000 (11/01–4/30)
100406	Flat River			300		400 (5/01–10/31) 2,000 (11/01–4/30)
100707	Castor Creek					400 (5/01–10/31) 2,000 (11/01–4/30)
100708	Castor Creek tributary		9	79		
100709	Grand Bayou					400 (5/01–10/31) 2,000 (11/01–4/30)
100710	Grand Bayou tributary	26	9	79		
100801	Saline Bayou					400 (5/01–10/31) 2,000 (11/01–4/30)
100804	Saline Bayou tributary		20	250		
100901	Bayou Nantaches					400 (5/01–10/31) 2,000 (11/01–4/30)
101101	Cane River	25		100		
101103	Bayou Kisatchie			100		400 (5/01–10/31) 2,000 (11/01–4/30)
101301	Rigolette Bayou					400 (5/01–10/31) 2,000 (11/01–4/30)
101303	Iatt Creek			100		
101401	Buhlow Lake				25	

[a] Criteria for primary and secondary contact recreation apply. Primary contact recreation: No more than 25 percent of the total samples collected on a monthly basis shall exceed a fecal coliform bacteria density of 400/100 mL. This shall apply only during the defined recreational period of 5/01 through 10/31. For all other periods, a fecal coliform bacteria density of 2,000/100 mL for secondary contact recreation applies.
Source: LDEQ 2005b

Primary contact water quality criteria for fecal coliform bacteria are applicable from May 1 through October 31. During the remainder of the year (November 1 through April 30), secondary contact criteria are applicable. For primary contact recreation, no more than 25 percent of the total samples may exceed a fecal coliform bacteria density of 400 colonies/100 mL. The samples should be collected on a monthly or near-monthly basis. Secondary contact criteria are similar to primary contact criteria in that no more than 25 percent of the total samples collected on a monthly or near-monthly basis may exceed a fecal coliform bacteria density of 2,000 colonies/100 mL.

Chloride

This report addresses two subsegments in the Red River Basin that are included on the Louisiana's 2004 section 303(d) list for chloride. The designated uses for each of the impaired segments are fish and wildlife propagation and drinking water supply for subsegment 101101 and fish and wildlife propagation for subsegment 100710. The designated use of fish and wildlife propagation includes the use of water for aquatic habitat, food, resting, reproduction, cover, or travel corridors for any indigenous wildlife and aquatic life species associated with the aquatic environment. The use also includes maintaining water quality at a level that prevents damage to native wildlife and aquatic species associated with the aquatic environment and prevents contamination of aquatic life consumed by humans. The drinking water supply designated use includes water used for human consumption and general household use (after conventional treatment) (LDEQ 2005b).

The applicable chloride criteria for subsegments 100710 and 101101 are 26 mg/L and 25 mg/L, respectively. These criteria apply at all times. The numerical criteria for chloride generally represent the arithmetic mean of existing data from the nearest sampling location plus 3 standard deviations.

Sulfate

Three Red River Basin subsegments included on Louisiana's 2004 section 303(d) list for sulfate are addressed in this report. All three subsegments are designated for fish and wildlife propagation.

The applicable sulfate criteria for the three subsegments are 9 mg/L (100708 and 100710) and 20 mg/L (100804). These criteria apply at all times. The numerical criteria for sulfate generally represent the arithmetic mean of existing data from the nearest sampling location plus 3 standard deviations.

Total Dissolved Solids

Seven of the subsegments included on the Louisiana's 2004 section 303(d) list for TDS impairments are addressed in this report (subsegments 100406, 100708, 100710, 100804, 101101, 101103, and 101303). Designated uses are fish and wildlife propagation (in subsegments 100406, 100708, 100710, 100804, 101101, 101103, and 101303) and drinking water supply (in subsegment 101101).

The applicable TDS criteria for the seven subsegments are 300 mg/L (100406), 79 mg/L (100708 and 100710), 250 mg/L (100804), and 100 mg/L (101101, 101103, and 101303). These criteria are applicable at all times. The numerical criteria for TDS generally represent the arithmetic mean of existing data from the nearest sampling location plus 3 standard deviations.

Turbidity

This TMDL report addresses only one of the subsegments listed as impaired by turbidity on Louisiana's 2004 section 303(d) list. That subsegment is 101401 (Buhlow Lake).

Louisiana's water quality standards (2005) state "turbidity other than that of natural origin shall not cause substantial visual contrast with the natural appearance of the waters of the state or impair any designated water use." Louisiana has a numerical criterion of 25 nephelometric turbidity units (NTU) for freshwater lakes in the state, and it is applied to subsegment 101401.

Antidegradation Policy

The Louisiana water quality standards also include an antidegradation policy (*Louisiana Administrative Code* [LAC] Title 33, Part IX, Section 1109.A), which states that state waters exhibiting high water quality should be maintained at that high level of water quality. If this is not possible, water quality of a level that supports the designated uses of the waterbody should be maintained. The designated uses of a waterbody may be changed to allow a lower level of water quality only through a use attainability study.

2.6 Point Sources

Information on point source discharges in the subsegments of concern was obtained from LDEQ files. LDEQ stores permit information using internal databases. Searches of the database yielded 33 point sources permitted to discharge fecal coliform bacteria, 26 for TDS, 3 for sulfate, 10 for chloride, and none for turbidity (Tables 2-7, 2-8, 2-9, and 2-10). Point source contributions from municipal wastewater systems are not expected to account for a large portion of the current fecal coliform bacteria loading.

Table 2-7. Point source discharge information for fecal coliform bacteria in the Red River Basin

Permit number	Facility name	Location	Outfall	Flow (gpd)[a]	Receiving water	Monthly average permit limit (colonies/ 100 mL)	Weekly average permit limit (colonies/ 100 mL)	Daily maximum permit limit (colonies/ 100 mL)
Subsegment 100709								
LAG380065	Fairview-Union Water System, Inc. Water Treatment Plant	3000 ft W of Hwy 507 N side of Parish Rd 110 adjacent to Grand Bayou Reservoir's spillway	1	270,591 (backwash max), 350 backwash avg	Grand Bayou		400	
LAG541039	Grand Bayou Reservoir Commission	LA Hwy 784, Coushatta, 71019	1	3600 (estimated avg)	Grand Bayou Reservoir	200	400	
LAG570196	South Pond	Ringgold, SEC. 10, T15N-R9W	1	< 100,000 (permitted flow)	Grand Bayou-Black Lake	200	400	
Subsegment 100801								
LA0097128	#1 Lagoon	Saline, S-27, T14N, R6W, end of Brown St	001 - Sanitary WW	37,000 50,000 (permitted flow)	Mill Creek-Saline Bayou	200	400	
LAG531052	Chevron Products Co. Arcadia Terminal (San D/C Only)	Arcadia 7453 Hwy 80	1	2000 avg (test) Sanitary wastewater up to 5,000	Irrigation Sprinkler Sys on Grass		400	
LAG560220	Village of Saline WWTF	170 Brown St; S-27, T14n, R6w, end of Brown St	1	40,000 < 50,000 (permitted flow)	Mill Creek	200	400	
Subsegment 100901								
LAG570224	Montgomery, town of—Facultative Lagoon	Hwy 34	1	90,000 < 100,000 (permitted flow)	Nantachie Creek	200	400	
Subsegment 101301								
LA0033456	Colfax Sewage Treatment Plant	Colfax, end of Richardson Drive	1	300,000	Sugarhouse Bayou-Bayou Rigolette	200	400	

Table 2-7. (continued)

Permit number	Facility name	Location	Outfall	Flow (gpd)[a]	Receiving water	Monthly average permit limit (colonies/ 100 mL)	Weekly average permit limit (colonies/ 100 mL)	Daily maximum permit limit (colonies/ 100 mL)
LA0039110	Aurora Park Subd	1/4 M S of US 71 & 167, off US 71	1	29,000 > 50,000 (permitted flow)	Creek-Rigolette Bayou-Red River	200	400	
LA0099457	Dresser Valve & Control Div	Alexandria Hwy 167 N & Hwy 3225	101 - Sanitary WW	34,000	Bayou Rigolette	200	400	
LAG530502	Tioga Main K4472	Tioga, 1201 Singer Dr	1	40 (estimated max)	Bayou Rigolette-Red River		400	
LAG530785	Hyams Trailer Park	Colfax, 544 Hudson Creek Rd.	1	20	Hudson Creek		400	
LAG540490	Tioga Manor Nursing Home	Pineville, 5201 Shreveport Hwy	1	16,400 (estimated avg)	Ditch-Bayou Rigolette	200	400	
LAG540610	Fort Buhlow Rec. Area Phase II Proj	Pineville, 201 Recreation Rd, 71360	1	10,000 (estimated avg)	Bayou Rigolette-Red R	200	400	
LAG560004	Haphazard Mobile Home Estate	Pineville, Hickory Hill Rd	1	29,700 < 50,000 (permitted flow)	Ditch-Rigolette Bayou	200	400	
LAG570042	Village of Provencal Sewer System	Provencal, East of		< 100,000 (permitted flow)	Edmund Bay-Provencal Bay-Kistachie	200	400	
Subsegment 100406								
LA0102890	Palmetto Park Oxidation Pond	Benton, S of, off Airline Dr	1 - Sanitary WW	400,000	Flat River	200	400	
LAG110003	Li Ready Mix 25 Shed Rd	Bossier City 3301 Shed Rd	102 - Treated Sanitary WW	5,000 (permitted flow)	Mack's Bayou		400	
LAG110003	Li Ready Mix 25 Shed Rd	Bossier City 3301 Shed Rd	202 - Treated Sanitary WW	5,000 (permitted flow)	Mack's Bayou		400	
LAG110144	REMCO Ready Mix	4461 Viking Dr, Bossier City, 71111	005	5,000 (permitted flow)	Mack's Bayou		400	
LAG470050	Red River Motor Co.	Bossier City 1940 Airline Hwy	005	828	Mack's Bayou		400	
LAG470050	Red River Motor Co.	Bossier City 1940 Airline Hwy	006	828	Mack's Bayou			400
LAG540038	The Winning Way Complex	Bossier 4 M N 220 on Benton Rd	001	9,700	Willow Chute Bayou	200	400	
LAG540188	Elm Grove Jr High Sch	Elm Grove, US Hwy 71, S of Bossier City, 1541old Hwy 71	001	11,420	Flat River-Loggy Bayou-Red River	200	400	
LAG540494	Maplewood Park	Bossier City, 4739 Benton Rd	001	25,000	Benoit Bayou-Alligator Bayou-Flat R	200	400	
LAG541141	Magnolia Chase Subdivision Sewage Treatment Facilities	Hwy 3	001	20,800 < 25,000 (permitted flow)	Willow Chute Bayou-Flat River	200	400	

Table 2-7. (continued)

Permit number	Facility name	Location	Outfall	Flow (gpd)[a]	Receiving water	Monthly average permit limit (colonies/ 100 mL)	Weekly average permit limit (colonies/ 100 mL)	Daily maximum permit limit (colonies/ 100 mL)
LAG541272	Eagle Water, Inc. - Haymeadow Subdivision	Hwy 3, N of	001	8,796 < 25,000 (permitted flow)	Williams Bayou-Willow Chute Bayou	200	400	
LAG541293	Eagle Water, Inc. - St Charles Court Sewer System - Construction	106 Decator Ct; Kingston Rd and Decatur	001	23,200 < 25,000 (permitted flow)	Willow Chute Bayou	200	400	
LAG560047	Haymeadow Utility Corp	Bossier City on Haymeadow Rd N of City, off Hwy 3	001	(Permitted flow = < 25,000)	Williams Bayou-Willow Chute Bayou	200	400	
LAG560063	Oak Creek Development, Inc.	5201 Tara Rd, Bossier City	001	< 25,000 (permitted flow) < 50,000 (permitted flow)	Willow Chute Bayou	200	400	
LAG560083	Eagle Water, Inc. - River Ridge Subdivision	end of River Rd	001	< 50,000 (permitted flow)	Flat River - Loggy Bayou	200	400	
LAG570255	Kingston Plantation Unit 2 - Construction	Kingston Rd in Bossier Parish	001	96,000 < 100,000 (permitted flow)	Willow Chute	200	400	

[a] gpd = gallons per day

Table 2-8. Point source discharge information for total dissolved solids in the Red River Basin

Permit number	Facility name	Location	Outfall	Flow (gpd)	Receiving water
Subsegment 100406					
LA0102890	Palmetto Park Oxidation Pond	Benton, S of, off Airline Dr	1 - Sanitary WW	400,000	Flat River
LAG110003	Li Ready Mix 25 Shed Rd	Bossier City 3301 Shed Rd	102 - Treated Sanitary WW	(Permitted flow = 5,000)	Mack's Bayou
LAG110003	Li Ready Mix 25 Shed Rd	Bossier City 3301 Shed Rd	202 - Treated Sanitary WW	(Permitted flow = 5,000)	Mack's Bayou
LAG110144	REMCO Ready Mix	4461 Viking Dr, Bossier City, 71111	005	(Permitted flow = 5,000)	Mack's Bayou
LAG470050	Red River Motor Co.	Bossier City, 1940 Airline Hwy	005	828	Mack's Bayou
LAG470050	Red River Motor Co.	Bossier City, 1940 Airline Hwy	006	828	Mack's Bayou
LAG540038	The Winning Way Complex	Bossier 4 M N 220 on Benton Rd	001	9,700	Willow Chute Bayou
LAG540188	Elm Grove Jr High Sch	Elm Grove, US Hwy 71, S of Bossier City, 1541 Old Hwy 71	001	11,420	Flat River-Loggy Bayou-Red River
LAG540494	Maplewood Park	Bossier City, 4739 Benton Rd	001	25,000	Benoit Bayou-Alligator Bayou-Flat R
LAG541141	Magnolia Chase Subdivision Sewage Treatment Facilities	Hwy 3	001	20,800 (Permitted flow = < 25,000)	Willow Chute Bayou-Flat River
LAG541272	Eagle Wate, Inc. - Haymeadow Subdivision	Hwy 3 N of	001	8,796 (Permitted flow = < 25,000)	Williams Bayou-Willow Chute Bayou

Table 2-8. (continued)

Permit number	Facility name	Location	Outfall	Flow (gpd)	Receiving water
LAG541293	Eagle Water, Inc. - St Charles Court Sewer System - Construction	106 Decator Ct; Kingston Rd and Decatur	001	23,200 (Permitted flow = < 25,000)	Willow Chute Bayou
LAG560047	Haymeadow Utility Corp	Bossier City on Haymeadow Rd N of City, off Hwy 3	001	20,160 (Permitted flow = < 25,000)	Williams Bayou-Willow Chute Bayou
LAG560063	Oak Creek Development Inc	5201 Tara Road, Bossier City	001	(Permitted flow = < 50,000)	Willow Chute Bayou
LAG560083	Eagle Water, Inc. - River Ridge Subdivision	end of River Rd	001	(Permitted flow = < 50,000)	Flat River - Loggy Bayou
LAG570255	Kingston Plantation Unit 2 - Construction	Kingston Rd in Bossier Parish	001	96,000 (Permitted flow = < 100,000)	Willow Chute
Subsegment 100708					
LAG560095	Castor, Village of, STP	Parish Rd 736, E of Hwy 153	001	<50,000	Castor Creek
Subsegment 100710					
LA0064611	Hall Summit, Village of, Sewerage System	Hwy 788 & Corbitt Dr	001	Design 0.050 MGD	Grand Bayou
Subsegment 100804					
LA0038504	Arcadia, Town of: Municipal Oxidation Pond	321 Tie Mill Rd	001	design 0.500 MGD	
Subsegment 101101					
LA0098078	Natchitoches Ph Mtce Unit	Natchitoches Hwy 1 & Hwy 1 Bypass	1 - Sanitary WW	(Permitted flow = 5,000)	Bayou Julien
LAG540047	Cedar Bend Subd Fka William & Ingram	Natchitoches off Hwy 494, on Riverview	001	3,900	Cane River
LAG540168	B&D Country Estates	Natchitoches, 1901 Hwy 1 South #465	001	18,000	Cane River
LAG540220	Cane River Apartments	Cloutierville, on School St, off La 495	001	8,800	Cane River
LAG540969	Highway 6 Trailer Park	Natchitoches 4431 Hwy 6 W of Town	001	6,000	Youngs Bayou-Bayou Boulet De Canon
LAG541068	Chopin Plywood Plant - 002	Chopin, W of Bayou Barbue, on Hwy 490e	002	10,000	Bayou Barbue
LAG541069	Pecan Grove Estates Mobile Home Park	Natchitoches, 298 Vienna Rd	001	9,000 ave.; 18,000 max.	Ditch To Bayou Poisson
LAG560008	Cedar Grove Subdivision	Natchitoches, off Hwy 494, Cedar Grove Dr	001	52,200 (Permitted flow = <100,000)	Cane River
LAG560013	Point Place Subdivision	Natchitoches, off Hwy 494, on Marie St	001	29,200 (Permitted flow = < 50,000)	Cane River
LAG570099	Payne Subdivision	Natchitoches, off Hwy 6, on Payne Dr	001	67,200 (Permitted flow = < 100,000)	Cane River

Table 2-9. Point source discharge information for sulfate in the Red River Basin

Permit number	Facility name	Location	Outfall	Flow (gpd)	Receiving water
Subsegment 100708					
LAG560095	Castor, village of—STP	Parish Rd 736, E of Hwy 153	001	< 50,000	Castor Creek
Subsegment 100710					
LA0064611	Hall Summit, Village of, Sewerage System	Hwy 788 & Corbitt Dr	001	Design 0.050 MGD	Grand Bayou
Subsegment 100804					
LA0038504	Arcadia, town of—Municipal Oxidation Pond	321 Tie Mill Rd	001	500,000	

Table 2-10. Point source discharge information for chloride in the Red River Basin

Permit number	Facility name	Location	Outfall	Flow (gpd)	Receiving water
Subsegment 100710					
LA0064611	Hall Summit, Village of, Sewerage System	Hwy 788 & Corbitt Dr	001	Design 0.050 MGD	Grand Bayou
Subsegment 101101					
LA0098078	Natchitoches Ph Mtce Unit	Natchitoches, Hwy 1 & Hwy 1 Bypass	1 - Sanitary WW	(Permitted flow = 5,000)	Bayou Julien
LAG540047	Cedar Bend Subd Fka William & Ingram	Natchitoches, off Hwy 494, on Riverview	001	3,900	Cane River
LAG540168	B&D Country Estates	Natchitoches, 1901 Hwy 1 South #465	001	18,000	Cane River
LAG540220	Cane River Apartments	Cloutierville, on School St, off LA 495	001	8,800	Cane River
LAG540969	Highway 6 Trailer Park	Natchitoches, 4431 Hwy 6 W of Town	001	6,000	Youngs Bayou-Bayou Boulet De Canon
LAG541068	Chopin Plywood Plant - 002	Chopin, W of Bayou Barbue, on Hwy 490e	002	10,000	Bayou Barbue
LAG541069	Pecan Grove Estates Mobile Home Park	Natchitoches, 298 Vienna Rd	001	9,000 ave.; 18,000 max.	ditch to Bayou Poisson
LAG560008	Cedar Grove Subdivision	Natchitoches, off Hwy 494, Cedar Grove Dr	001	52,200 (Permitted flow = < 100,000)	Cane River
LAG560013	Point Place Subdivision	Natchitoches, off Hwy 494, on Marie St	001	29,200 (Permitted flow = < 50,000)	Cane River
LAG570099	Payne Subdivision	Natchitoches, off Hwy 6, on Payne Dr	001	67,200 (Permitted flow = < 100,000)	Cane River

Phase I and II stormwater systems are another possible point source contributor in the Red River Basin. Stormwater discharges are generated by runoff from urban land and impervious areas such as paved streets, parking lots, and rooftops during precipitation events, and these discharges often contain high concentrations of pollutants that can eventually enter nearby waterbodies. Most stormwater discharges are considered point sources and require coverage by a National Pollutant Discharge Elimination System (NPDES) permit.

Under the NPDES stormwater program, operators of large, medium, and regulated small municipal separate storm sewer systems (MS4s) require authorization to discharge pollutants. The Stormwater Phase I Rule (55 *Federal Register* 47990; November 16, 1990) requires all operators of medium and large MS4s to obtain an NPDES permit and develop a stormwater management program. Medium and large MS4s are defined by the size of the population within the MS4 area, not including the population served by combined sewer systems. A medium MS4 has a population size between 100,000 and 249,999. A large MS4 has a population of 250,000 or more. The only Phase I MS4 in the Red River Basin is Shreveport, Louisiana.

Phase II requires a select subset of small MS4s to obtain an NPDES stormwater permit. A small MS4 is any MS4 not already covered by the Phase I program as a medium or large MS4. The Phase II Rule automatically covers all small MS4s in urbanized areas (UAs), as defined by the Bureau of the Census, and also includes small MS4s outside a UA that are so designated by NPDES permitting authorities, case by case (USEPA 2000).

In Louisiana, there are two ways that an MS4 can be identified as a regulated small MS4. This category includes all cities within UAs and any small MS4 area outside UAs with a population of at least 10,000 and a population density of at least 1,000 people per square mile (LDEQ 2002a). Table 2-11 presents MS4 information by subsegment for the Red River Basin.

Table 2-11. MS4 information for the Red River Basin

Subsegment number	Subsegment name	Urban area	MS4 area (acres)	Phase I or II
100306	Kelly Bayou	Shreveport	1,833.3	Phase I
101101	Cane River	Natchitoches	548.4	Phase II
101301	Rigolette Bayou	Alexandria	111.5	Phase II
101401	Buhlow Lake	Alexandria	200.2	Phase II

2.7 Nonpoint Sources

Fecal Coliform Bacteria

Louisiana's 2004 section 303(d) list identifies managed pasture grazing, wildlife other than waterfowl, and natural conditions as the suspected nonpoint sources of the fecal coliform bacteria impairment in the Red River Basin subsegments. Additional potential sources of fecal coliform bacteria not included on the section 303(d) list are failing septic or sewer systems. The subsegments with managed pasture identified as the potential source contain pasture/hay land use areas of 18.1 (subsegment 100306), 17.1 (subsegment 100406), and 1.5 percent (subsegment 101103). Managed pasture grazing involves livestock production in managed grasslands, which are usually used for hay production as well. The subsegments that have identified wildlife and natural conditions as the potential source are dominated by forest (83.2 [100707], 65.3 [100709], and 81.4 [100801] percent), which provides more habitat for non-aquatic wildlife than do non-forested watersheds and might account for the increased fecal coliform bacteria loads from wildlife.

Chloride

The state's section 303(d) list identifies natural conditions as potential nonpoint sources of chloride in the Red River Basin. Additional sources are unknown. Typically, sources of dissolved minerals include urban and agricultural runoff, forestry, and natural geology. Chloride is found in all human and animal wastes, and therefore septic systems and areas where animal wastes are deposited can be chloride sources. Fertilizers are also a common source of chlorides (University of Florida 2003).

Sulfate

The state's section 303(d) list identifies natural conditions as potential nonpoint sources of sulfate in the Red River Basin. Additional sources are unknown. Sulfate is a naturally occurring mineral in some soils and rock formations. Sources of dissolved minerals often include urban and agricultural runoff, forestry, and geology.

Total Dissolved Solids

The state's section 303(d) list identifies residential districts and natural conditions as potential nonpoint sources of TDS in the Red River Basin. Additional sources are unknown. TDS can originate from natural sources (e.g., mineral springs, carbonate deposits, salt deposits, seawater intrusion) and urban and agricultural runoff (Wilkes University 2005). LDEQ's 2000 *Nonpoint Source Annual Report* suggests that soil erosion is a major problem in subsegment 100406 (Flat River), along with nutrients related to fertilizer usage (LDEQ 2000a). The Flat River watershed is mostly cropland with some pasture/hay areas.

Turbidity

This report addresses only one subsegment listed for turbidity, 101401 (Buhlow Lake). The state's section 303(d) list identifies natural conditions as the suspected source. LDEQ officials suspect that the turbidity impairment in Buhlow Lake is due to recent construction in the watershed. A fun-park for children was recently constructed near the lake, and a number of new homes were built along Rocky Bayou, which is a tributary to Buhlow Lake. There has also been new road construction in the watershed. All this construction is nearly completed, and LDEQ expects that the turbidity levels in the lake will soon return to their previous levels and will once again meet the turbidity criteria (Bob Paul, LDEQ Kisatchie Regional Office, personal communication, July 26, 2005).

3 CHARACTERIZATION OF EXISTING WATER QUALITY

3.1 Comparison of Observed Data to Criteria

Fecal Coliform Bacteria

Of the eight subsegments listed for fecal coliform bacteria impairments on Louisiana's 2004 section 303(d) list, only three have observations at more than one water quality station; the other five subsegments have only one data set per subsegment. Table A-1 in Appendix A presents a summary of the observations at each water quality station by subsegment, including the number of observations; the minimum, maximum, and median observations; the number of exceedances of the criteria; and the percentage of observations exceeding criterion at each station. Appendix B contains the original water quality data.

The station with the most fecal coliform bacteria observations is station 42 on subsegment 101103 (Bayou Kisatchie), with 213 observations collected between 1978 and 1998. The least amount of observations at any station is 12 at stations 1192 (subsegment 100306), 1189 (subsegment 100707), 1190 (subsegment 100709), 1215 (subsegment 100901), and 1220 (subsegment 101301).

Exceedances of the summer primary contact recreation criterion (400/100 mL) from May 1 through October 31 were observed at all stations, with the highest percentage of exceedances (50 percent) at station 1189 in subsegment 100707 (Castor Creek). The other exceedances range from 17 to 37 percent.

Four of the eight subsegments have exceedances of the winter criterion (2,000/100 mL), which is applied from November 1 through April 30. The highest percentage of winter exceedances is 16 percent at station 56 on Kelly Bayou. The lowest percentage of winter exceedances is 2 percent at station 75 on Saline Bayou. Station 272 on the Flat River has the largest single sample concentration[1], with an observation of 240,000/100 mL in August 1994.

Chloride

One chloride data set is available for each of the chloride-impaired subsegments addressed in this TMDL report. Water quality station 1195 has chloride observations for subsegment 100710 (Grand Bayou Tributary), and station 1217 has observations on the Cane River in subsegment 101101. Table A-2 in Appendix A presents a summary of the observations at each water quality station by subsegment, including the number of observations; the minimum, maximum, and median observations; the number of exceedances of the criteria; and the percentage of observations exceeding criterion at each station. Appendix B contains the original water quality data.

Station 1195 has nine observations from January to December 2002, and 56 percent of the observations exceed the 26 mg/L chloride criterion for the unnamed tributary. Station 1217 has

[1] This result is the largest that was specifically identified. Several sample concentrations were given as "greater than" a certain concentration, and the actual concentration could be larger than the one listed here as the largest.

16 observations from January 2002 through April 2004 and 31 percent of the observations exceed the 25 mg/L chloride criterion for the Cane River.

Sulfate

One sulfate data set is available for each of the sulfate-impaired subsegments addressed in this TMDL report. Water quality station 1194 has sulfate observations for subsegment 100708 (unnamed tributary of Castor Creek), station 1195 has observations for subsegment 100710 (unnamed tributary of Grand Bayou), and station 1206 has observations for subsegment 100804 (unnamed tributary of Saline Bayou). Table A-3 in Appendix A presents a summary of the observations at each water quality station by subsegment, including the number of observations; the minimum, maximum, and median observations; the number of exceedances of the criteria; and the percentage of observations exceeding criterion at each station. Appendix B contains the original water quality data.

All three stations have sulfate observations for January through December of 2002. Stations 1194 and 1195 each have nine observations, while station 1206 has 12 observations. Station 1195 has the highest percentage of exceedances of the criterion (78 percent). Stations 1194 and 1206 have exceedances of 67 percent and 75 percent, respectively.

Total Dissolved Solids

Of the seven TDS-impaired subsegments addressed in this report, two have four water quality stations with TDS observations. The remaining subsegments have one station each. Table A-4 in Appendix A presents a summary of the observations at each water quality station by subsegment, including the number of observations; the minimum, maximum, and median observations; the number of exceedances of the criteria; and the percentage of observations exceeding criterion at each station. Appendix B contains the original water quality data.

All but two of the stations show TDS observations that exceed the TDS criterion for each subsegment. The two stations that do not have exceedances are 549 and 550 in subsegment 101103 (Kisatchie Bayou), but there are only two observations at each of these stations. The highest percentage of exceedances was observed at station 1195, on subsegment 100710 (unnamed tributary to Grand Bayou). All nine of the observations at station 1195, sampled during 2002, exceed the 79 mg/L criterion for subsegment 100710. The smallest percentage of exceedances is 33 percent at station 1206 in subsegment 100804 (unnamed tributary to Saline Bayou).

Turbidity

There is one water quality station (1223) for subsegment 101401 (Buhlow Lake), which is included on Louisiana’s 2004 section 303(d) list for turbidity impairment. Table A-5 in Appendix A presents a summary of the observations at station 1223, including the number of observations; the minimum, maximum, and median observations; the number of exceedances of the criteria; and the percentage of observations exceeding criterion at the station. Appendix B contains the original water quality data.

There are 12 turbidity observations at station 1223 for the period of record January through December 2002. The maximum observation is 69 NTU, and the minimum is 19 NTU. Seventy-five percent of the turbidity observations at station 1223 exceed the 25 NTU turbidity criterion for Buhlow Lake.

3.2 Trends and Patterns in Observed Data

Fecal Coliform Bacteria

Because of the limited number of samples at most of the water quality stations, no distinct trends or patterns were seen in the fecal coliform bacteria data results. The highest fecal coliform bacteria concentrations were observed during the summer months and usually during low-flow conditions, but not many samples were collected during high-flow periods for comparison. Higher concentrations would be expected at high-flow conditions after a precipitation event when the fecal coliform bacteria have the potential to be washed off the pastureland into the waterbody. Appendix C contains the fecal coliform bacteria sampling results plotted over time and versus flow.

Chloride

The chloride observations at station 1195 in subsegment 100710 (unnamed tributary to Grand Bayou) do not show any strong trends or patterns, but the highest observations tended to be in the winter and early spring months of 2002. There is no trend related to streamflow. However, the chloride observations at station 1217 in subsegment 101101 (Cane River) show a strong relationship with flow. The highest concentrations were consistently observed at lower flows. Appendix D contains the chloride sampling results plotted over time and versus flow.

Sulfate

Stations 1194 and 1195 at subsegments 100708 and 100710, respectively, both show higher sulfate concentrations during the winter than during the summer, but there is no strong correlation with flow. Station 1206 on subsegment 100804 shows no seasonal trends, but there is a correlation with higher concentrations at lower flows. Appendix E contains the sulfate sampling results plotted over time and versus flow.

TDS

In general, most of the water quality stations in subsegments listed for TDS did not show strong seasonal or hydrologic trends. Stations 272 (subsegment 100406), 1206 (subsegment 100804), 1217 (subsegment 101101), and 42 (subsegment 101103) did show an increase in TDS concentrations at lower flows, but not many observations were made at higher flows for comparison. Appendix F contains the TDS sampling results plotted over time and versus flow.

Turbidity

Station 1223 at Buhlow Lake (subsegment 101401) showed higher turbidity observations in the late summer and winter months during the samples that were collected (January through December 2002). Because of the limited number of samples (only 12), however, no other distinct trends or patterns were seen in the data. Appendix G contains the turbidity sampling results plotted over time and versus flow.

4 TMDL DEVELOPMENT

A TMDL is the total amount of a pollutant that can be assimilated by the receiving waterbody while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide the basis for establishing water quality-based controls.

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. This TMDL also includes a future growth (FG) component to account for loadings from the continued growth in the TMDL area. The TMDL components are illustrated using the following equation:

$$TMDL = \sum WLAs + \sum LAs + MOS + FG$$

For some pollutants, TMDLs are expressed on a mass loading basis (e.g., kilograms per day). For bacteria, however, TMDLs can be expressed in terms of organism counts (or resulting concentration), in accordance with 40 CFR 130.2(l).

4.1 TMDL Analytical Approach

The methodology used to determine the TMDL for each impaired subsegment is the load duration curve. Because loading capacity varies as a function of the flow present in the stream, these TMDLs represent a continuum of desired loads over all flow conditions, rather than a fixed single value. The basic elements of this procedure are documented on the Kansas Department of Health and Environment Web site (KDHE 2003). This method was used to illustrate allowable loading for a wide range of flows. The steps for how this methodology was applied for the TMDLs in this report can be summarized as follows:

1. Develop a flow duration curve.
2. Convert the flow duration curve to load duration curves for each impairment.
3. Plot observed loads with load duration curves.
4. Calculate TMDL, MOS, FG, WLA, and LA (see Section 4.2).
5. Calculate percent reductions required to meet assessment criteria.

Flow Duration Curve

A flow per unit area duration curve was developed for each USGS gage for the TMDLs. Daily streamflow measurements from USGS gages for each data set were sorted in increasing order, and the percentile ranking of each flow was calculated. For fecal coliform bacteria, the daily streamflow measurements from USGS gages were separated into summer (May through October) and winter (November through April) data sets to accommodate for the state’s seasonal criteria. The load duration methodology requires that the same flow period be used for both developing the flow duration and calculating observed loads from sampling data. For each season, the flows per unit area were then plotted against the corresponding percent flow that exceeds a specific flow to create the flow duration curves.

Figure 4-1 is an example of a flow duration curve. The plot shows the flow per unit area (e.g., cubic feet per second per square mile) on the Y-axis. The X-axis shows the percentage of days on which the plotted flow is exceeded. Points at the lower end of the plot (0 through 10 percent) represent high-flow conditions where only 0 through 10 percent of the flow exceeds the plotted point. Conversely, points on the high end of the plot (90 to 100 percent) represent low-flow conditions.

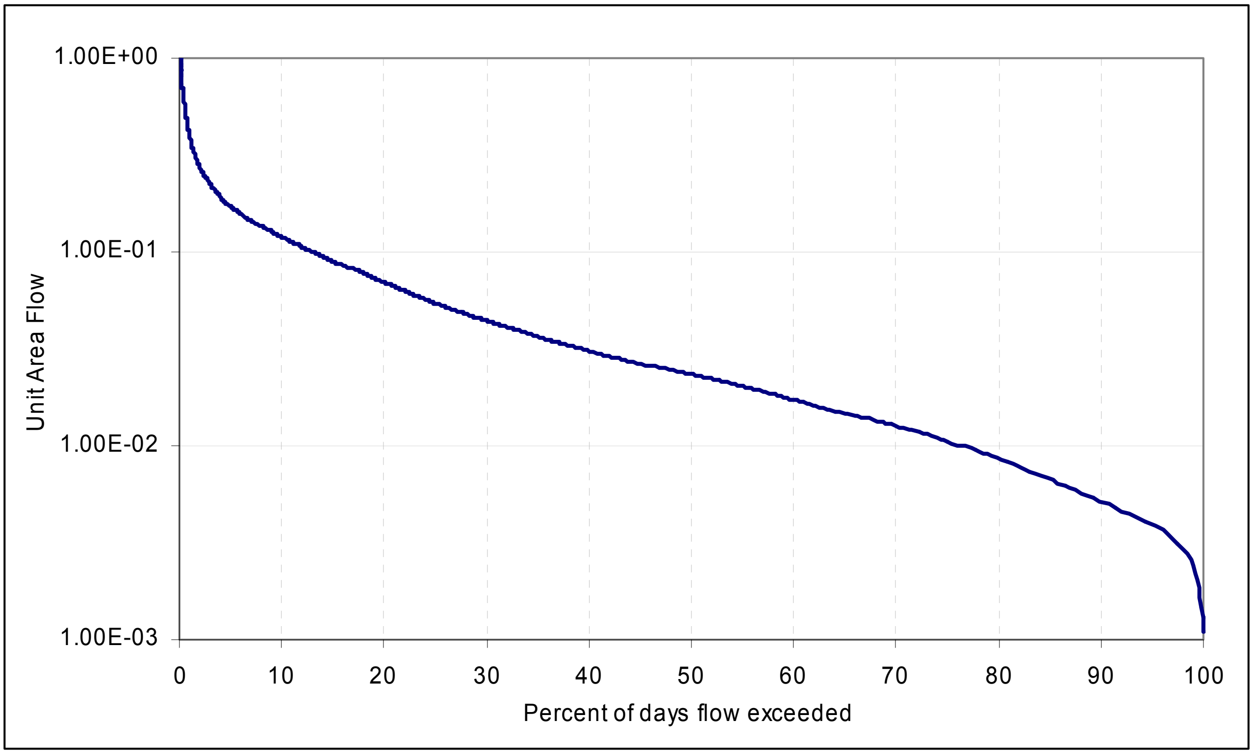

Figure 4-1. Example of load duration curve.

Because there was only one active USGS gage in the area of concern, four other nearby gages in similar watersheds were assigned to each subsegment to represent flow. Many USGS gages in the area were not used because their period of record did not intersect the period of record for the water quality data. Other USGS gages were not used because they were not representative of the subsegments of interest. Table 4-1 presents each USGS gage that was used, the period of record used in the TMDL analysis, and the subsegment(s) it represents.

For the TMDL calculations, the most recent flow data were used. Data from 1980 through 2003 were used for USGS gages 07373000 and 08028000. For USGS gages 07348700 and 07352000, data for some recent water years (1993 and 1996) were missing. Data from 1962 through 2002 were used to maintain the quality assurance guidelines of 95 percent data completeness. USGS gage 0737860 had a period of record of 1980 through 2003; however, the completeness of the data did not meet quality assurance guidelines. Some recent water years (1993 and 1996) were missing and the gage had only 90 percent data completeness. Nevertheless, this information was used in the TMDL calculations because it was the best available data.

Table 4-1. USGS flow gages and represented subsegments for the Red River Basin

Station number	Station name	Period of record used in TMDL development	Subsegments represented
07348700	Bayou Dorcheat near Springhill, LA	1/1/1980–9/30/2003	100306
07349860	Red Chute Bayou at Sligo, LA	7/10/1980–9/30/2003	100406
07352000	Saline Bayou near Lucky, LA	1/1/1980–9/30/2003	100707, 100708, 100709, 100710, 100801, 100804
07373000	Big Creek at Pollack, LA	1/1/1980–9/30/2002	100901, 101301, 101303, 101401
08025500	Bayou Toro near Toro, LA	1/1/1980–9/30/2002	101101, 101103

Load Duration Curve

For each TMDL parameter (TSS, chloride, TDS, and sulfates) and each season for fecal coliform bacteria, the flows per unit area from the flow duration curves were multiplied by the appropriate target concentration (Table 2-6) to compute an allowable load per unit area duration curve. Each load duration curve is a plot of mass per day per subsegment area versus the percent flow exceedance from the flow duration curves. Because the load duration curves were expressed by unit of drainage area, each curve was assumed applicable at all sampling stations and for all stream reaches in that subsegment.

The load duration curve is beneficial when analyzing monitoring data with their corresponding flow information plotted as a load. This approach allows the monitoring data to be placed in relation to their place in the flow continuum. Assumptions of the probable source or sources of the impairment can then be made from the plotted data. The load duration curve shows the calculation of the TMDL at any flow rather than at a single critical flow. The official TMDL number is reported as a single number, but the curve is provided to demonstrate the value of the acceptable load at any flow. This will allow analysis of load cases in the future for different flow regimes.

Because turbidity is a measure of the water's optical properties that cause light to be scattered or absorbed, the load duration curve and the percent reduction were based on a surrogate parameter, total suspended solids (TSS). Turbidity can be affected by different suspended particles such as clay, silt, and microorganisms, many of which are the same substances that form TSS. Turbidity can also be affected by algae and watercolor; however, for these TMDLs, TSS is assumed the dominant source of turbidity. Because the state of Louisiana has not developed numeric criteria for TSS, a regression analysis of turbidity and TSS data was performed. Only one subsegment, 101401, is listed for turbidity. The regression equation ($y = 0.9243x + 8.0405$, where y is TSS and x is turbidity) had an R^2 value of 0.66. This value demonstrates that there is a correlation between turbidity and TSS, albeit not strong one, and that TSS can be used as a surrogate.

For TMDL calculations (Appendix H), the calculated TSS endpoint was compared to existing TSS data. Results from these calculations are used in this report and as the loads assigned to the watersheds. An alternative method of determining the TMDL and percent reduction is to use TSS concentrations that are calculated the same way the end point is. TMDLs and percent reductions were calculated in this manner, and provided similar, often identical loads and percent reductions. These calculations are included in Appendix H for comparison.

Observed Loads

For each sampling station (and season for fecal coliform bacteria), observed loads were calculated by multiplying the observed concentration of the parameter of concern by the flow per unit area on the sampling day. These observed loads were then plotted versus the percent flow exceedance of the flow per unit area on the sampling day and placed on the same plot as the load duration curve. Reductions were applied to the observed loads for each parameter until its water quality criteria and allowable percent exceedance were met to obtain an overall percent reduction for each subsegment. These plots are shown in the appendices of this report as follows:

Appendix H: Load Duration Calculations for all TMDLs (CD-ROM)
Appendix I: Red River Basin Load Duration Curve and Plot for Total Suspended Solids
Appendix J: Red River Basin Load Duration Curves and Plots for Chloride
Appendix K: Red River Basin Load Duration Curves and Plots for Total Dissolved Solids
Appendix L: Red River Basin Load Duration Curves and Plots for Sulfate
Appendix M: Red River Basin Load Duration Curves and Plots for Fecal Coliform Bacteria: Summer
Appendix N: Red River Basin Load Duration Curves and Plots for Fecal Coliform Bacteria: Winter

These plots provide visual comparisons between observed and allowable loads under different flow conditions. Observed loads that are plotted above the load duration curve represent conditions where observed water quality concentrations exceed the target concentrations. Observed loads plotted below the load duration curve represent conditions where observed water quality concentrations were less than target concentrations (i.e., not exceeding water quality standards).

4.2 TMDL, WLA, and LA

Each TMDL was calculated as the area under the load duration curve. Because the load duration curves were expressed in mass per unit drainage area, the area under the curve was multiplied by the estimated subsegment area, which was assumed to represent the drainage area for the subsegment. Table 4-2 presents the TMDLs and allocations for the subsegments in this report.

Both section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs include an MOS to account for uncertainty in available data or in the actual effect that controls will have on the loading reductions and receiving water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly using conservative assumptions in establishing the TMDL. For a more detailed discussion of the MOS, see Section 4.4. In addition to the MOS, an FG component was added for an additional MOS to account specifically for future growth in the TMDL area (see Section 4.5).

Table 4-2. Summary of fecal coliform bacteria TMDLs, MOS, FG, WLAs, and LAs for Red River Basin

Subsegment	Station	Season	Percent reduction	Total allowable load	Explicit MOS (10%)	Future growth (10%)	∑ WLA	∑ LA
				1×10^9 colonies/day				
100306	56	Summer	54.4	21.76	2.18	0.00	12.99	6.59
100306	56	Winter	0.0	372.30	37.23	0.00	222.32	112.75
100406	272	Summer	48.6	62.32	6.23	6.23	5.90	43.95
100406	272	Winter	0.0	602.60	60.26	60.26	5.90	476.18
100707	1189	Summer	55.0	17.52	1.75	0.00	1.75	14.02
100707	1189	Winter	0.0	291.16	29.12	0.00	29.12	232.93
100709	1190	Summer	28.0	64.88	6.49	6.49	0.79	51.11
100709	1190	Winter	0.0	1,083.34	108.33	108.33	0.79	865.89
100801	75	Summer	0.0	144.65	14.47	14.47	0.86	114.86
100801	75	Winter	0.0	2,415.52	241.55	241.55	0.86	1,931.55
100901	1215	Summer	77.5	56.33	5.63	5.63	0.76	44.30
100901	1215	Winter	0.0	632.08	63.21	63.21	0.76	504.91
101103	1218	Summer	77.5	205.84	20.58	0.00	20.58	164.67
101103	1218	Winter	0.0	2,991.37	299.14	0.00	299.14	2,393.09
101301	1220	Summer	0.0	129.85	12.98	12.98	5.21	98.67
101301	1220	Winter	0.0	1,457.13	145.71	145.71	16.78	1,148.93

Table 4-3. Summary of chloride and sulfate TMDLs, MOS, FG, WLAs, and LAs for Red River Basin

Subsegment	Station	Pollutant	Percent reduction	Total allowable load	Explicit MOS (10%)	Future growth (10%)	∑ WLA	∑ LA
				kg/day				
100710	1195	Chloride	59.2	10.24	1.02	1.02	4.92	3.27
101101	1217	Chloride	51.9	2,374.26	237.43	237.43	118.47	1,780.94
100708	1194	Sulfate	54.5	10.88	1.09	1.09	5.68	3.03
100710	1195	Sulfate	85.9	3.54	0.35	0.35	1.70	1.13
100804	1206	Sulfate	0.0	51.33	5.13	5.13	37.85	3.21

Table 4-4. Summary of TDS and TSS TMDLs, MOS, FG, WLAs, and LAs for Red River Basin

Subsegment	Station	Pollutant	Percent reduction	Total allowable load	Explicit MOS (10%)	Future growth (10%)	∑ WLA	∑ LA
				ton/day				
100406	389	TDS	48.7	9.70	0.97	0.97	1.35	6.41
100708	1194	TDS	43.6	0.09	0.01	0.01	0.02	0.05
100710	1195	TDS	65.3	0.03	0.00	0.00	0.02	0.01
100804	1206	TDS	51.9	0.71	0.07	0.07	0.52	0.04
101101	1217	TDS	76.6	10.47	1.05	1.05	0.77	7.61
101103	42	TDS	76.7	11.34	1.13	1.13	0.00	9.08
101303	1222	TDS	63.4	4.36	0.44	0.44	0.00	3.49
101401	1223	Tur/TSS	43.3	0.04	Implicit	0.00	0.02	0.01

Hurricane Katrina made landfall on Monday, August 29, 2005, as a Category 4 hurricane. The storm brought heavy winds and rain to southeast Louisiana, breaching several levees and flooding up to 80 percent of New Orleans and large areas of coastal Louisiana. Much of the area that was flooded during Hurricane Katrina was flooded again by the storm surge from Hurricane Rita. Both Hurricanes Katrina and Rita have caused a significant amount of change in sedimentation and water quality in southern Louisiana. Many wastewater treatment facilities were temporarily or permanently damaged. Some wastewater treatment facilities will be rebuilt while others will be relocated. The hurricanes expedited the loss of coastal land and modified the hydrology of some of the coastal waterbodies. Several federal and state agencies including the EPA and LDEQ are engaged in collecting environmental data and assessing the recovery of the Gulf of Mexico waters. The proposed TMDLs in this report were developed on the basis of pre-hurricane conditions. Therefore, post-hurricane conditions and other factors could delay the implementation of these proposed TMDLs, render some proposed TMDLs obsolete, or could require modifications of the TMDLs.

Much of coastal Louisiana was built by the process of delta formation through flooding and deposition of sediments by the rise and fall of the Mississippi River. According to EPA's present knowledge, extensive areas of wetlands and coastal marshes are affected by a high rate of subsidence and degradation, primarily due to a lack of historical sediment and nutrients entering the wetlands. Subsidence is a natural process, but the building of levee systems has restricted the Mississippi River's course and, therefore, is preventing the natural cycle of the river and the natural process of delta formation. According to EPA, a large portion of the state's coastal wetlands have undergone and continue to undergo severe deprivation of sediments and nutrients that has led to the breakup of the natural system. In addition, EPA believes that many of Louisiana's wetlands have become isolated from the riverine sources that created them and are becoming stagnant and starved for nutrients and organic and inorganic sediments. Note that restoring these eroding wetlands involves supplying nutrients to these areas through managed Mississippi River diversions.

According to EPA's understanding, if any future diversion from the Mississippi River or other tributaries will increase flow, the nonpoint source load allocation and TMDLs will also be increased proportionately. From EPA's current understanding, the diversion projects are supported by both state and federal agencies, including EPA and the U.S. Army Corps of Engineers (USACE). The diversions are managed by the USACE and the state, and the projects include post-diversion monitoring to determine effectiveness of the project and to monitor water quality conditions.

Wasteload Allocation

The WLA portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. The point sources in the Red River Basin include wastewater facilities and MS4s. Wasteload allocations are based on the current permit limits and discharge flow levels.

No domestic wastewater facilities with permit limits for chloride, sulfate, and/or TDS could be found in the Red River Basin, although it is possible that discharges from such facilities could have slightly elevated levels of these parameters. Therefore, these facilities were given WLAs based on assumed effluent concentrations. From samples collected by LDEQ in field surveys from Cotton Valley Sewage Treatment Plant (STP), City of Minden trickling filter plant, City of Springhill STP, and City of Houma South Plant, median values of chloride (58 mg/L) and TDS (425 mg/L) concentrations in measured effluent were used in the calculations. For sulfate, 30 mg/L (Metcalf and Eddy, Inc. 1991)–a literature value for medium-strength domestic wastewater–was used. The median values for chloride and TDS derived from the field survey were similar to those in Metcalf and Eddy, Inc. (1991); therefore, it was assumed that using the sulfate value from this study was appropriate.

It should be noted that because area normalized flow is small in three subsegments (100708, 100710, and 100804), which have large permitted flows, an additional flow was added to the area normalized flow. This additional flow was set equal to the permitted flow in the point sources in the particular subsegment to account to the large permitted flow that was not previously accounted for. The flow was added because of several factors that include the relatively small size of the subsegment and the relative magnitude of the estimated effluent concentration compared to the water quality criteria. The stream water quality criteria for certain parameters are low compared to observed levels of the domestic wastewater facilities, which were used to derive the effluent concentrations used in this TMDL.

No nondomestic wastewater facilities with permit limits for chloride, sulfate, or TDS are in these subsegments. Therefore, it was assumed that none of these facilities has elevated concentrations and no WLAs were assigned. No wastewater facilities were included in the TMDL for turbidity because it appears that the only facilities that contribute to turbidity are small or remote and, therefore, are not significant.

For fecal coliform bacteria, LDEQ’s policy is to set wastewater permit limits no higher than water quality criteria (i.e., criteria are met at end-of-pipe). As long as point source discharges of treated wastewater contain parameter levels at or below these permit limits, they should not be a cause of exceedances of the fecal coliform bacteria water quality criteria. Therefore, no change in the permit limits is required. Tables 4-5 through 4-8 list the individual fecal coliform bacteria, chloride, sulfate, and TDS WLAs for each point source in the Red River Basin.

EPA’s stormwater permitting regulations require municipalities to obtain permit coverage for all stormwater discharges from MS4s. For each MS4 in the basin, a gross MS4 load was computed by multiplying the LA by the ratio of the MS4 area in each subsegment to the subsegment area in the Red River Basin. It should be noted that these values are estimates that can be refined in the future as more information about the MS4s and land use-specific loadings information becomes available. It should also be noted that the MS4 loads presented reflect only that portion of the MS4 in the subsegment. The computed MS4 load was subtracted from the LA and included as a WLA component of the TMDL because MS4s are permitted dischargers but function similarly to nonpoint sources through storm-driven processes. Tables 4-9 and 4-10 list the individual WLAs for the MS4s identified in Section 2.6 (Table 2-7).

Table 4-5. Fecal coliform bacteria WLAs for the Red River Basin

Permit Number	Outfall	Permitted flow (gpd)	Fecal coliform monthly avg (colonies/ 100 mL)[a]	Fecal coliform weekly avg (colonies/ 100 mL)[a]	Fecal coliform daily max (colonies/ 100 mL)[a]	Fecal load (1×10^6 colonies/ day)[a]
Subsegment 100406						
LA0102890	1	400,000	200	400	--	3,028.00
LAG110003	102	5,000	--	400	--	75.70
LAG110003	202	5,000	--	400	--	75.70
LAG110144	005	5,000	--	400	--	75.70
LAG470050	005	828	--	400	--	12.54
LAG470050	006	828	--	--	400	12.54
LAG540038	001	9,700	200	400	--	73.43
LAG540188	001	11,420	200	400	--	86.45
LAG540494	001	25,000	200	400	--	189.25
LAG541141	001	25,000	200	400	--	189.25
LAG541272	001	25,000	200	400	--	189.25
LAG541293	001	25,000	200	400	--	189.25
LAG560047	001	25,000	200	400	--	189.25
LAG560063	001	50,000	200	400	--	378.50
LAG560083	001	50,000	200	400	--	378.50
LAG570255	001	100,000	200	400	--	757.00
					Total	**5,900.30**
Subsegment 100709						
LAG380065	001	350	--	400	--	5.30
LAG541039	001	3,600	200	400	--	27.25
LAG570196	001	100,000	200	400	--	757.00
					Total	**789.55**
Subsegment 100801						
LA0097128	001	50,000	200	400	--	378.50
LAG531052	001	5,000	--	400	--	75.70
LAG531052	001	2,000	--	400	--	30.28
LAG560220	001	50,000	200	400	--	378.50
					Total	**862.98**
Subsegment 100901						
LAG570224	001	100,000	200	400	--	757.00
					Total	**757.00**
Subsegment 101301						
LA0033456	001	300,000	200	400	--	2,271.00
LA0039110	001	50,000	200	400	--	378.50
LA0099457	101	18,000	200	400	--	136.26
LAG530502	001	40	--	400	--	0.61
LAG530785	001	20	--	400	--	0.30
LAG540490	001	16,400	200	400	--	124.15
LAG540610	001	10,000	200	400	--	75.70
LAG560004	001	50,000	200	400	--	378.50
LAG570042		100,000[b]	200[b]	400[b]	--	757.00
					Total	**4,122.02**

Table 4-5. (continued)

[a] Monthly average permit limits, when applicable, were used to calculate the load. When permit does not have a monthly average permit limit, the weekly average permit limit was used. If the facility has neither a monthly nor a weekly limit, the daily maximum limit was used to calculate loads.
[b] This flow is standard for general permits with this number. Permit limits are general permit limits for monthly average and daily maximum in summer.

Table 4-6. Chloride WLAs for the Red River Basin

Permit number	Outfall	Permitted flow (gpd)	Estimated chloride limit (mg/L)	Chloride load (kg/day)
Subsegment 100710				
LA0064611	001	50,000	26	4.9
			Total	**4.9**
Subsegment 101101				
LA0098078	1	5,000	58	1.1
LAG540047	001	3,900	58	0.9
LAG540168	001	18,000	58	4.0
LAG540220	001	8,800	58	1.9
LAG540969	001	6,000	58	1.3
LAG541068	002	10,000	58	2.2
LAG541069	001	9,000	58	2.0
LAG560008	001	100,000	58	22.0
LAG560013	001	50,000	58	11.0
LAG570099	001	100,000	58	22.0
			Total	**68.2**

Table 4-7. Sulfate WLAs for the Red River Basin

Permit number	Outfall	Permitted flow (gpd)	Estimated sulfate limit (mg/L)	Sulfate loading (kg/day)
Subsegment 100708				
LAG560095	001	50,000	30	5.7
			Total	**5.7**
Subsegment 100710				
LA0064611	001	50,000	9	1.7
			Total	**1.7**
Subsegment 100804				
LA0038504	001	500,000	20	37.9
			Total	**37.9**

Table 4-8. TDS WLAs for the Red River Basin

Permit number	Outfall	Permitted flow (gpd)	Estimated TDS limit (mg/L)	TDS load (tons/day)
Subsegment 100406				
LA0102890	1	400,000	425	0.71
LAG110003	102	5,000	425	0.01
LAG110003	202	5,000	425	0.01
LAG110144	005	5,000	425	0.01
LAG470050	005	828	425	0.00

Table 4-8. (continued)

Permit number	Outfall	Permitted flow (gpd)	Estimated TDS limit (mg/L)	TDS load (tons/day)
LAG470050	006	828	425	0.00
LAG540038	001	9,700	425	0.02
LAG540188	001	11,420	425	0.02
LAG540494	001	25,000	425	0.04
LAG541141	001	25,000	425	0.04
LAG541272	001	25,000	425	0.04
LAG541293	001	25,000	425	0.04
LAG560047	001	25,000	425	0.04
LAG560063	001	50,000	425	0.09
LAG560083	001	50,000	425	0.09
LAG570255	001	100,000	425	0.18
			Total	**1.35**
Subsegment 100708				
LAG560095	001	50,000	79	0.02
			Total	**0.02**
Subsegment 100710				
LA0064611	001	50,000	79	0.02
			Total	**0.02**
Subsegment 100804				
LA0038504	001	500,000	250	0.52
			Total	**0.52**
Subsegment 101101				
LA0098078	1 - Sanitary WW	5,000	425	0.01
LAG540047	001	3,900	425	0.01
LAG540168	001	18,000	425	0.03
LAG540220	001	8,800	425	0.02
LAG540969	001	6,000	425	0.01
LAG541068	002	10,000	425	0.02
LAG541069	001	9,000	425	0.02
LAG560008	001	100,000	425	0.18
LAG560013	001	50,000	425	0.09
LAG570099	001	100,000	425	0.18
			Total	**0.55**

Table 4-9. Fecal coliform bacteria WLAs for MS4s for the Red River Basin

Subsegment number	Subsegment name	Urban area	Season	MS4 area (acres)	MS4 WLA (1×10^9 colonies/ day)
100306	Kelly Bayou	Shreveport	Summer	1,833	10.8
100306	Kelly Bayou	Shreveport	Winter	1,833	185.1
101301	Rigolette Bayou	Alexandria	Summer	112	1.1
101301	Rigolette Bayou	Alexandria	Winter	112	12.7

Table 4-10. Chloride, TDS, and turbidity/TSS WLAs for MS4s for the Red River Basin

Subsegment number	Subsegment name	Pollutant	Urban area	MS4 Area (acres)	MS4 WLA	WLA units
101101	Cane River	Chloride	Natchitoches	548	50.26	kg/day
101101	Cane River	TDS	Natchitoches	548	0.215	ton/day
101401	Buhlow Lake	Turbidity/TSS	Alexandria	200	0.021	ton/day

Load Allocation

The load allocation is the portion of the TMDL assigned to natural background loadings as well as nonpoint sources such as septic tank leakage, wildlife, and agricultural practices. For this TMDL that LA was calculated by subtracting the WLA, MOS, and FG from the total TMDL. LAs were not allocated to separate nonpoint sources; due to the lack of available source characterization data. The LAs are presented in Tables 4-2 and 4-3.

4.3 Seasonality and Critical Conditions

The federal regulations at 40 CFR 130.7 require that TMDLs include seasonal variations and take into account critical conditions for streamflow, loading, and water quality parameters. For this TMDL, fecal coliform bacteria loadings for subsegments with primary contact recreation as the designated use were determined for winter and summer on the basis of seasonal water quality criteria, thus accounting for seasonality. In addition, the sampling results for all pollutants were plotted over time and reviewed for any seasonal patterns (see Section 3.2).

By accounting for critical conditions, the TMDL makes sure that water quality standards are maintained for infrequent occurrences and not only for average conditions. For fecal coliform bacteria, the water quality criteria include values that must not be exceeded more than 25 percent of the time (primary and secondary contact recreation).

Because of the way the criteria are written (i.e., including critical and noncritical conditions), the TMDL for the pollutant of concern can be developed by reviewing pollutant loads at all flow conditions within applicable periods of the year and evaluating the percentage of values exceeding the criteria. The load duration curve, which determines the allowable loading at a wide range of flows, was chosen as the approach for these TMDLs (see Section 4.1). Therefore, the TMDLs were calculated at all flows rather than at a single critical flow.

4.4 Margin of Safety

The MOS is the portion of the pollutant loading reserved to account for any uncertainty in the data. There are two ways to incorporate the MOS (USEPA 1991). One way is to implicitly incorporate the MOS by using conservative model assumptions to develop allocations. The other way is to explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For all pollutants except turbidity in this analysis, the MOS is explicit: 10 percent of each targeted TMDL was reserved as the MOS to account for any uncertainty in the TMDL. Using 10 percent of the TMDL load provides an additional level of protection to the designated uses of the subsegments of concern. For the turbidity TMDL, an implicit MOS was incorporated through by using conservative assumptions. The primary conservative assumption was calculating the turbidity TMDLs assuming that TSS is a conservative parameter and does not settle out of the water column.

4.5 Future Growth

While the MOS is an allocation for scientific uncertainly, future growth is an allocation for growth. Ten percent of the load was allocated for future growth in the area that is covered by the TMDL. This includes future urban development, including point sources and MS4 areas, and agricultural and other typical nonpoint source contributing areas.

5 FUTURE WATERSHED ACTIVITIES

5.1 TMDL Implementation Strategies

Wasteload allocations will be implemented through Louisiana Pollutant Discharge Elimination System (LPDES) permit procedures.

Load allocations will be addressed through the LDEQ Nonpoint Source Management Program. Louisiana's *Nonpoint Source Management Plan* (LDEQ 2000b) states that TMDLs are being developed through a close relationship between LDEQ and EPA Region 6. It further states that "management strategies outlined within this document (both statewide and watershed) will be implemented in each of the watersheds where water quality problems have been attributed to nonpoint sources of pollution." On page ii, Objective 3 of the watershed management strategies is to "utilize pollutant load reductions of the TMDL to develop nonpoint source pollution reduction strategies for each of the watersheds...that have water quality problems identified." In addition, Objective 7 provides a tracking process for evaluating progress in reducing loadings of fecal coliform bacteria.

The plan includes a discussion of a number of nonpoint source activities and provides best management practices (BMPs) that can be used to achieve the nonpoint source load reductions established in the TMDLs. The plan broadly discusses programs to address agriculture, forestry, home sewer treatment systems, hydromodification, urban runoff, construction, and resource extraction. Provided with each BMP is an evaluation of the effectiveness of the BMP, given as a high, medium, or low ranking. Additional evaluations should be conducted to determine the most likely source of impairment in this watershed and to identify localized hot spots to be targeted for effective BMP implementation. These and other BMPs may be implemented at a scale adequate to achieve the load reductions established in the TMDL.

5.2 Water Quality Monitoring Activities

LDEQ uses funds provided under section 106 of the federal Clean Water Act and under the authority of the Louisiana Environmental Quality Act to run a program for monitoring the quality of the state's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations using appropriate sampling methods and procedures to ensure the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, develop a long-term database for water quality trend analysis, and monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program are used to develop the state's biennial section 305(b) report (*Water Quality Inventory*) and the section 303(d) list of impaired waters. This information is also used in establishing priorities for LDEQ's nonpoint source program.

LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled on a 4-year cycle. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the 4-year cycle. Sampling is conducted monthly to yield approximately 12 samples per site during each year the site is monitored. Sampling sites are located where they are considered representative of the waterbody. Under the current monitoring schedule, approximately one-half of the state's waters are newly assessed for section 305(b) and section 303(d) listing purposes for each biennial cycle, with sampling occurring statewide each year. The 4-year cycle follows an initial 5-year rotation that covered all basins in the state according to the TMDL priorities. Monitoring will allow LDEQ to determine whether there has been any improvement in water quality following implementation of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the section 303(d) list of impaired waterbodies.

6 PUBLIC PARTICIPATION

Federal regulations require EPA to notify the public and seek comment concerning TMDLs that the Agency prepares. This TMDL was developed under contract to EPA, and EPA is seeking comments, information, and data from the public and any other interested party. Comments and additional information submitted during this public comment period will be used to inform or revise this TMDL. The comments and responses will be included in an appendix in the final draft of this TMDL. EPA will submit the final TMDL to LDEQ for implementation and incorporation into LDEQ's current water quality management plan.

7 REFERENCES

KDHE (Kansas Department of Health and Environment). 2003. *Kansas TMDL Curve Methodology*. Web site maintained by Kansas Department of Health and Environment. <http://www.kdheks.gov/tmdl/basic.htm>. Dated September 29, 2003.

LDEQ (Louisiana Department of Environmental Quality). 2000a. *Nonpoint Source Annual Report*. <www.nonpoint.deq.state.la.us/2000NPS_annual report.pdf>.

LDEQ (Louisiana Department of Environmental Quality). 2000b. *Nonpoint Source Management Plan*. Louisiana Department of Environmental Quality. Baton Rouge, LA.

LDEQ (Louisiana Department of Environmental Quality). 2002a. Office of Environmental Services Water Discharge Permit, Final: Discharges from Small Municipal Separate Storm Sewer Systems. LDEQ, Baton Rouge, LA.

LDEQ (Louisiana Department of Environmental Quality). 2002b. *Water Quality Inventory Report*. Prepared pursuant to section 305(b) of the Federal Water Pollution Control Act. <http://www.deq.state.la.us/planning/305b/2002/index.htm>.

LDEQ (Louisiana Department of Environmental Quality). 2005a. *Louisiana 2004 303(d) List*. Dated August 17, 2005. <http://www.deq.louisiana.gov/portal/tabid/130/Default.aspx>.

LDEQ (Louisiana Department of Environmental Quality). 2005b. *Environmental Regulatory Code*. Part IX. Water Quality Regulations. Chapter 11. Surface Water Quality Standards. <http://www.deq.state.la.us/planning/regs/title33/index.htm>.

Metcalf and Eddy, Inc. 1991. *Wastewater Engineering Treatment, Disposal and Reuse,* 3rd ed. Revised by George Tchobanoglous and Franklin L. Burton. McGraw-Hill, Inc., New York.

University of Florida. 2003. *Plant Management in Florida Waters: Chloride*. The Center for Aquatic and Invasive Plants, the University of Florida, the Bureau of Invasive Plant Management, Florida Department of Environmental Protection. <http:/aquat1.ifas.ufl.edu/guide/chlori.html>.

USEPA (United States Environmental Protection Agency). 1991. *Guidance for Water Quality-Based Decisions: The TMDL Process*. EPA 440/-4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2000. *Storm Water Phase II Final Rule.* (Fact sheet). EPA 833-F-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Wilkes University. 2005. *Total Dissolved Solids*. Wilkes University, Center for Environmental Quality GeoEnvironmental Sciences and Engineering Department. <www.water-research.net/totaldissolvedsolids.htm>.

Wischmeier, W.H., and D.D. Smith. 1978. *Predicting Rainfall Erosion Losses—A Guide to Conservation Planning*. Agricultural Handbook No. 537. U.S. Department of Agriculture, Washington, D.C.

Appendix A
Summary of Water Quality Data

Table A-1. Summary of fecal coliform bacteria data for the Red River Basin

Station number	Station name	Period of record	Number of observations	Minimum MPN/ 100ml	Maximum MPN/ 100ml	Mean MPN/ 100ml	Median MPN/ 100ml	Number of observations above criterion[a]	% of observations above criterion[a]
May 1 through October 31									
Subsegment 100306									
56	Kelly Bayou near Hosston, LA	5/8/78–10/9/89	64	8	24,000	1900	225	23	36%
1192	Kelly Bayou at Huckaby Road, south of Hosston, LA	5/6/02–10/7/02	6	110	1,600	458	205	2	33%
Subsegment 100406									
272	Flat River east of Taylortown, LA	6/11/90–10/15/02	29	8	240,000	9230	220	10	34%
363	Flat River Drainage Canal north of Bossier City, LA	No Data							
389	Flat River Drainage Canal NE of Bossier City, LA	No Data							
390	Flat River Drainage Canal NE of Shreveport, LA	No Data							
Subsegment 100707									
1189	Castor Creek at Highway 507, southwest of Castor, LA	5/13/02–10/14/02	6	50	1,600	578	400	3	50%

Table A-1. (continued)

Station number	Station name	Period of record	Number of observations	Minimum MPN/ 100ml	Maximum MPN/ 100ml	Mean MPN/ 100ml	Median MPN/ 100ml	Number of observations above criterion[a]	% of observations above criterion[a]
Subsegment 100709									
1190	Grand Bayou at Highway 507, north of Fairview Alpha, LA	5/13/02–10/14/02	6	17	1,600	433	215	2	33%
Subsegment 100801									
75	Saline Bayou near Goldonna, LA	6/12/78–10/7/02	105	1	16,000	843	140	19	18%
284	Saline Bayou east of Bienville, LA	6/11/90–10/14/97	24	7	1,100	202	85	4	17%
553	Saline Bayou near Goldonna, LA	No Data							
Subsegment 100901									
1215	Nantachie Creek east of Montgomery, LA	5/20/02–10/21/02	6	23	1,600	592	150	2	33%
Subsegment 101103									
42	Kisatchie Bayou near Lotus, LA	5/9/78–10/13/97	107	7	9,400	649	170	31	29%
549	Kisatchie Bayou at Kisatchie, LA	No Data							
550	Little Sandy Creek at Kisatchie, LA	No Data							
1218	Kisatchie Bayou south of Cypress, LA	5/20/02–10/21/02	6	30	1,600	650	270	2	33%

Table A-1. (continued)

Station number	Station name	Period of record	Number of observations	Minimum MPN/ 100ml	Maximum MPN/ 100ml	Mean MPN/ 100ml	Median MPN/ 100ml	Number of observations above criterion[a]	% of observations above criterion[a]
Subsegment 101301									
556	Cress Creek west of Oak Grove, LA	No Data							
1220	Rigolette Bayou northwest of Pineville, LA	5/21/02–10/22/02	6	4	2,400	509	72	2	33%
November 1 through April 30									
Subsegment 100306									
56	Kelly Bayou near Hosston, LA	4/11/78–12/11/89	62	13	13,000	1,008	150	10	16%
1192	Kelly Bayou at Huckaby Road, south of Hosston, LA	1/8/02–12/2/02	6	30	500	173	110	0	0%
Subsegment 100406									
272	Flat River east of Taylortown, LA	2/12/90–12/10/02	32	8	22,000	1428	120	4	13%
363	Flat River Drainage Canal north of Bossier City, LA	No Data							
389	Flat River Drainage Canal NE of Bossier City, LA	No Data							

Table A-1. (continued)

Station number	Station name	Period of record	Number of observations	Minimum MPN/ 100ml	Maximum MPN/ 100ml	Mean MPN/ 100ml	Median MPN/ 100ml	Number of observations above criterion[a]	% of observations above criterion[a]
390	Flat River Drainage Canal NE of Shreveport, LA	No Data							
Subsegment 100707									
1189	Castor Creek at Highway 507, southwest of Castor, LA	1/14/02–12/9/02	6	110	1,600	568	335	0	0%
Subsegment 100709									
1190	Grand Bayou at Highway 507, north of Fairview Alpha, LA	1/14/02–12/9/02	6	11	240	79	38	0	0%
Subsegment 100801									
75	Saline Bayou near Goldonna, LA	11/13/78–12/2/02	100	10	9,200	312	130	2	2%
284	Saline Bayou east of Bienville, LA	2/13/90–4/14/98	25	6	11,000	715	79	2	8%
553	Saline Bayou near Goldonna, LA	No Data							
Subsegment 100901									
1215	Nantachie Creek east of Montgomery, LA	1/28/02–12/16/02	6	30	300	132	130	0	0%

Table A-1. (continued)

Station number	Station name	Period of record	Number of observations	Minimum MPN/ 100ml	Maximum MPN/ 100ml	Mean MPN/ 100ml	Median MPN/ 100ml	Number of observations above criterion[a]	% of observations above criterion[a]
Subsegment 101103									
42	Kisatchie Bayou near Lotus, LA	4/11/78–4/14/98	106	8	9,000	565	130	9	8%
549	Kisatchie Bayou at Kisatchie, LA	No Data							
550	Little Sandy Creek at Kisatchie, LA	No Data							
1218	Kisatchie Bayou south of Cypress, LA	1/28/02–2/4/04	8	80	500	254	205	0	0%
Subsegment 101301									
556	Cress Creek west of Oak Grove, LA	No Data							
1220	Rigolette Bayou northwest of Pineville, LA	1/22/02–12/17/02	6	9	1,600	325	23	0	0%

[a] Primary contact recreation water quality criteria for fecal coliform bacteria: No more than 25 percent of the total samples collected on a monthly or near-monthly basis shall exceed a fecal coliform density of 400/100mL from May 1 through October 31. During the nonrecreational period of November 1 through April 30, the criteria for secondary contact recreation shall apply (no more than 25 percent of the total samples collected on a monthly or near-monthly basis shall exceed a fecal coliform density of 2,000/100mL).

Table A-2. Summary of chloride data for the Red River Basin

Station number	Station name	Period of record	Number of observations	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)	Median (mg/l)	Number of observations above criterion[a]	% of observations above criterion[a]
Subsegment 100710									
1195	Unnamed tributary of Grand Bayou near Hall Summit, LA	1/15/02–12/10/02	9	15.6	57.3	35.6	36.1	5	56%
Subsegment 101101									
1217	Cane River west of Colfax, LA	1/28/02–4/20/04	16	3.9	46.8	16.7	11.15	5	31%

[a] The water quality criteria for chloride in the Red River Basin are as follows:
Subsegment 100710: 26 mg/L
Subsegment 101101: 25 mg/L

Table A-3. Summary of sulfate data for the Red River Basin

Station number	Station name	Period of record	Number of observations	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)	Median (mg/l)	Number of observations above criterion[a]	% of observations above criterion[a]
Subsegment 100708									
1194	Unnamed tributary of Castor Creek near Castor, LA	1/14/02–12/9/02	9	2.6	163	10	92	6	67%
Subsegment 100710									
1195	Unnamed tributary of Grand Bayou near Hall Summit, LA	1/15/02–12/10/02	9	6.4	26.5	14.8	11	7	78%
Subsegment 100804									
1206	Unnamed tributary of Saline Bayou near Arcadia, LA	1/14/02–12/9/02	12	4.5	123	38	33.25	9	75%

[a] The water quality criteria for sulfate in the Red River Basin are as follows:
Subsegment 100708: 9 mg/L
Subsegment 100710: 9 mg/L
Subsegment 100804: 20 mg/L

Table A-4. Summary of total dissolved solids data for the Red River Basin

Station number	Station name	Period of record	Number of observations	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)	Median (mg/l)	Number of observations above criterion[a]	% of observations above criterion[a]
Subsegment 100406									
272	Flat River east of Taylortown, LA	2/12/90–12/10/02	61	114	754	398	392	43	70%
363	Flat River Drainage Canal north of Bossier City, LA	11/14/90–12/12/94	51	148	450	303	300	25	49%
389	Flat River Drainage Canal northeast of Bossier City, LA	11/14/90–12/12/94	50	168	576	298	291	20	40%
390	Flat River Drainage Canal northeast of Shreveport, LA	11/14/90–12/12/94	49	146	432	285	288	24	49%
Subsegment 100708									
1194	Unnamed tributary of Castor Creek near Castor, LA	1/14/02–12/9/02	9	44	126	91	87	7	78%

Table A-4. (continued)

Station number	Station name	Period of record	Number of observations	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)	Median (mg/l)	Number of observations above criterion[a]	% of observations above criterion[a]
Subsegment 100710									
1195	Unnamed tributary of Grand Bayou near Hall Summit, LA	1/15/02–12/10/02	9	144	205	173	169	9	100%
Subsegment 100804									
1206	Unnamed tributary of Saline Bayou near Arcadia, LA	1/14/02–12/9/02	12	64	468	237	228	4	33%
Subsegment 101101									
1217	Cane River west of Colfax, LA	1/28/02–4/20/04	16	85	384	191	156	15	94%
Subsegment 101103									
42	Kisatchie Bayou near Lotus, LA	3/6/78–4/14/98	227	32	386	103	100	108	48%
549	Kisatchie Bayou at Kisatchie, LA	10/14/96–11/18/96	2	34	54	44	44	0	0%
550	Little Sandy Creek at Kisatchie, LA	10/14/96–11/18/96	2	26	67.9	46.95	46.95	0	0%
1218	Kisatchie Bayou south of Cypress, LA	1/28/02–4/20/04	16	80	163	99	92	6	38%

Table A-4. (continued)

Station number	Station name	Period of record	Number of observations	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)	Median (mg/l)	Number of observations above criterion[a]	% of observations above criterion[a]
Subsegment 101303									
1222	Iatt Creek southeast of Iatt, LA	1/28/02–12/16/02	16	80	163	112	92	6	67%

[a] The water quality criteria for TDS in the Red River Basin are as follows:

Subsegment 100406: 300 mg/L
Subsegment 100708: 79 mg/L
Subsegment 100710: 79 mg/L
Subsegment 100804: 250 mg/L
Subsegment 101101: 100 mg/L
Subsegment 101103: 100 mg/L
Subsegment 101303: 100 mg/L

Table A-5. Summary of turbidity data for the Red River Basin

Station number	Station name	Period of record	Number of observations	Minimum (NTU)	Maximum (NTU)	Mean (NTU)	Median (NTU)	Number of observations above criterion[a]	% of observations above criterion[a]
Subsegment 101401									
1223	Buhlow Lake northwest of Pineville, LA	1/28/02–12/16/02	12	19	69	37	36	9	75%

[a] Turbidity criterion for Subsegment 101401: 25 NTU.

Appendix C
Fecal Coliform Bacteria Figures for Red River Basin

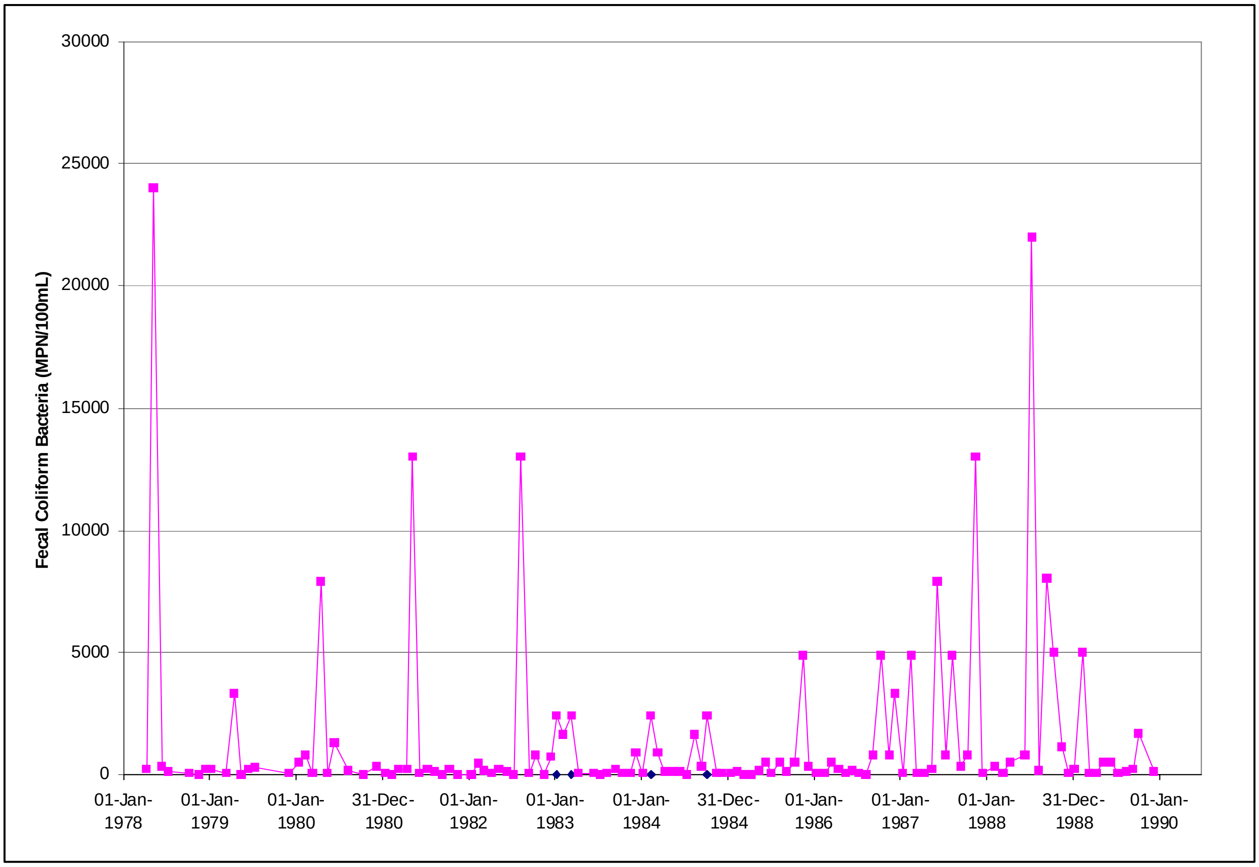

Figure C-1. Fecal coliform bacteria observations at Kelly Bayou (subsegment 100306) near Hosston, Louisiana (station 56).

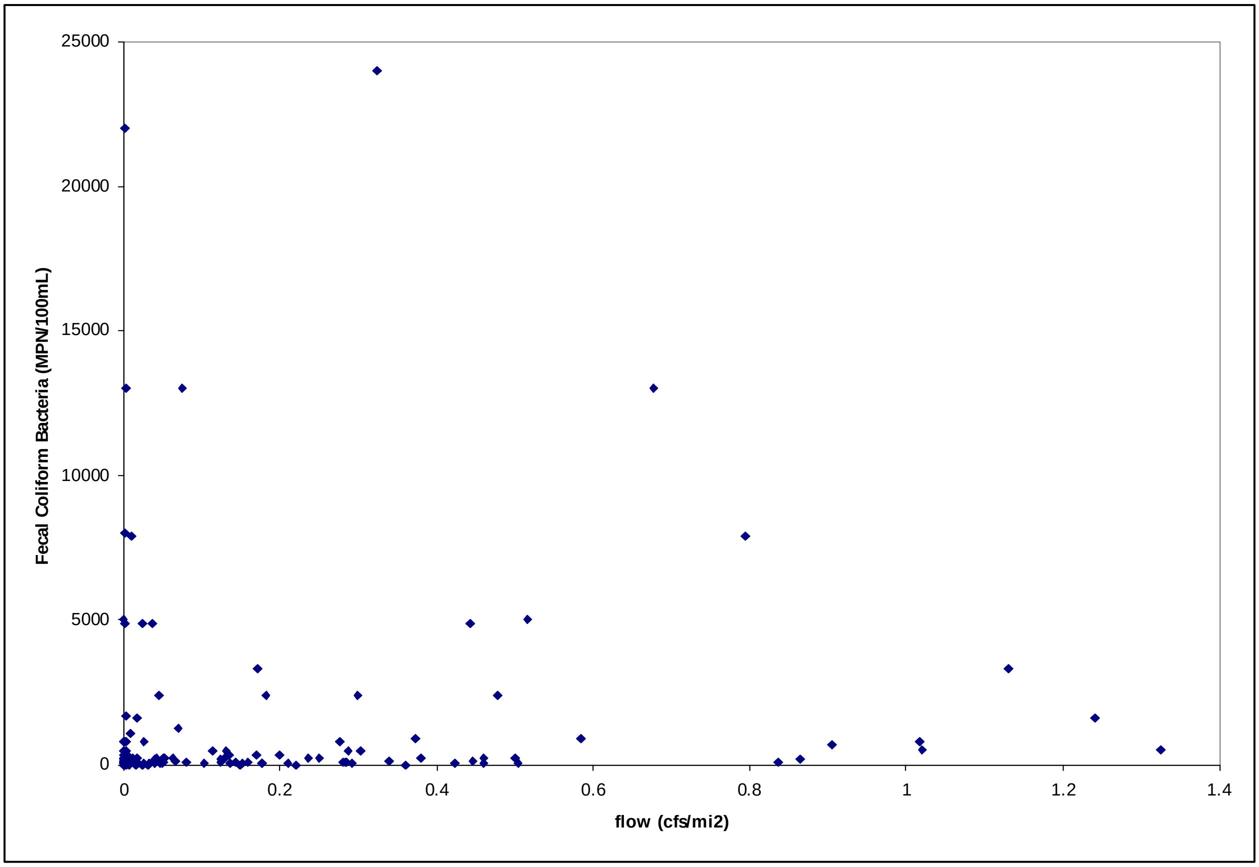

Figure C-2. Fecal coliform bacteria versus flow at Kelly Bayou (subsegment 100306) near Hosston, Louisiana (station 56).

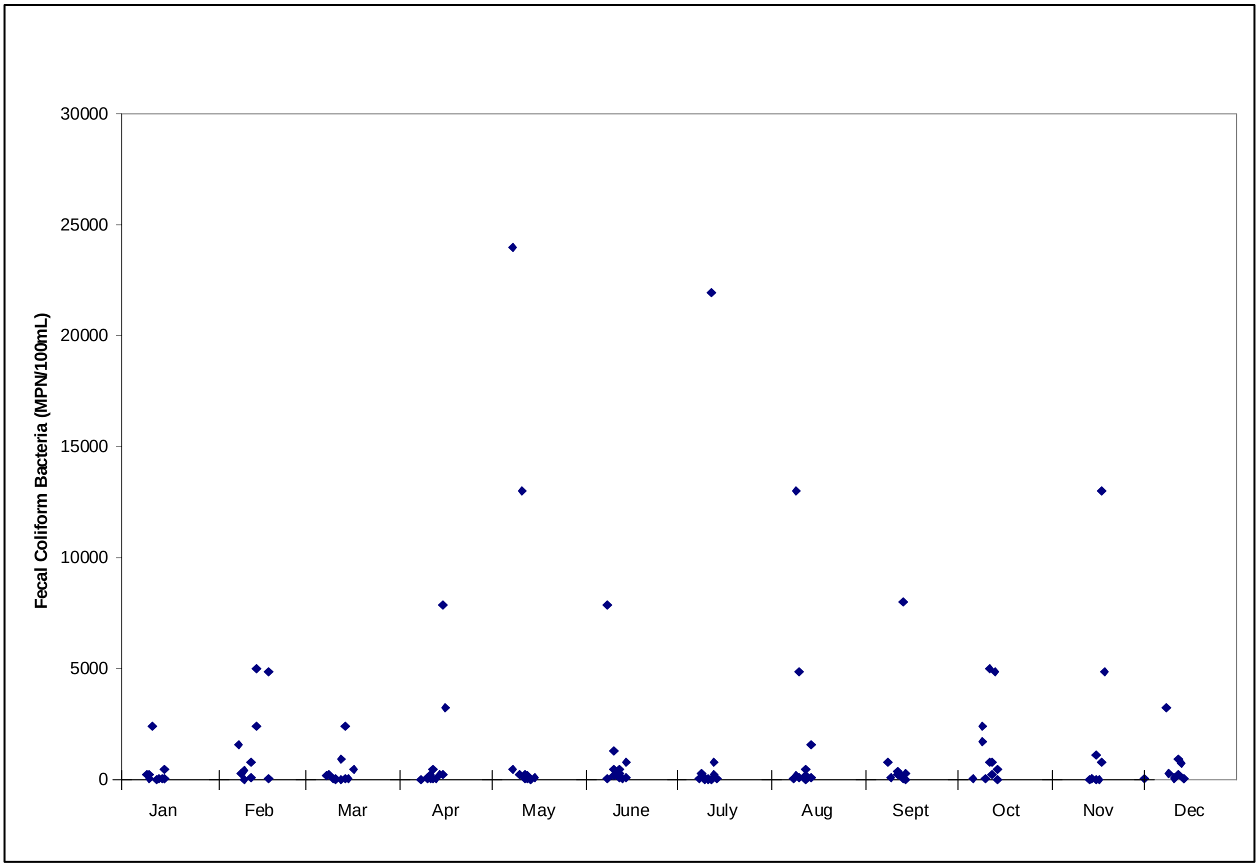

Figure C-3. Fecal coliform bacteria observations by season at Kelly Bayou (subsegment 100306) near Hosston, Louisiana (station 56).

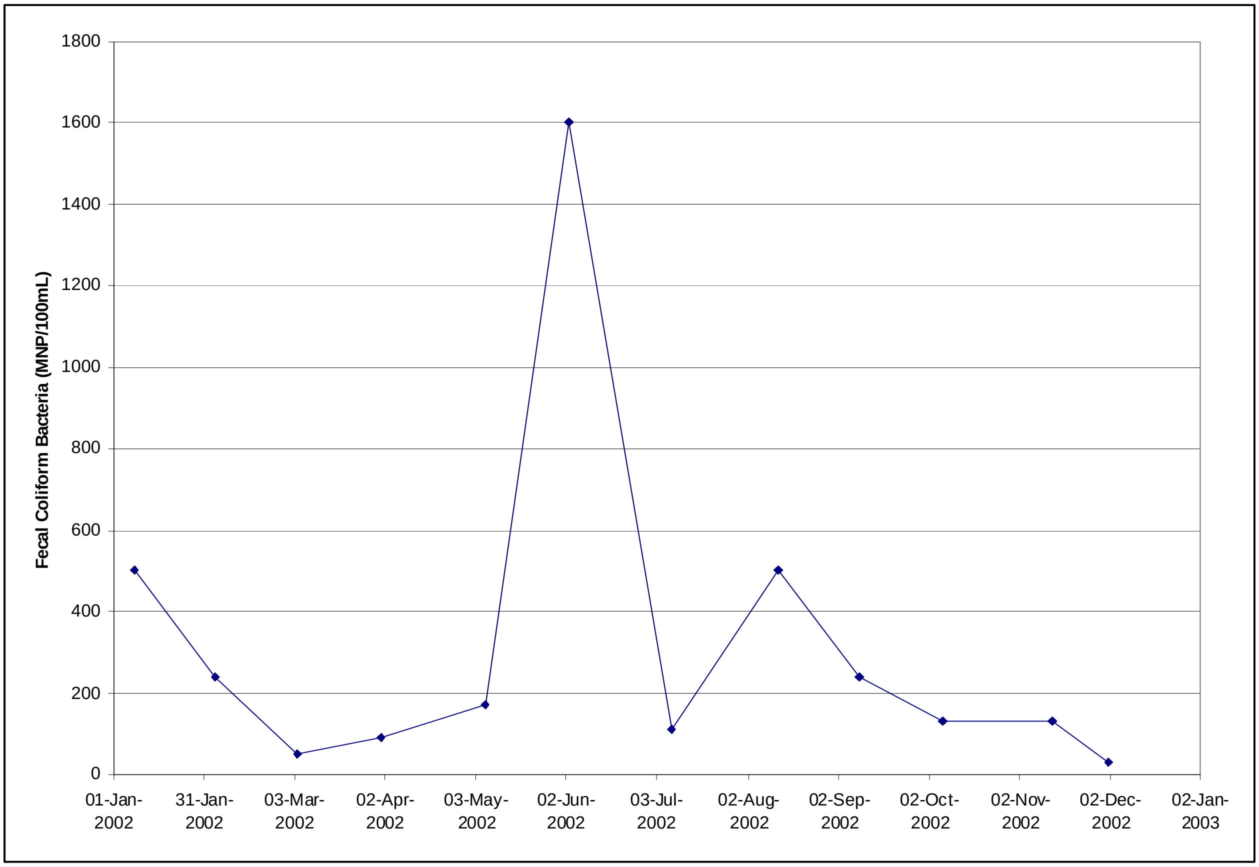

Figure C-4. Fecal coliform bacteria observations at Kelly Bayou (subsegment 100306) at Huckaby Road near Hosston, Louisiana (station 1192).

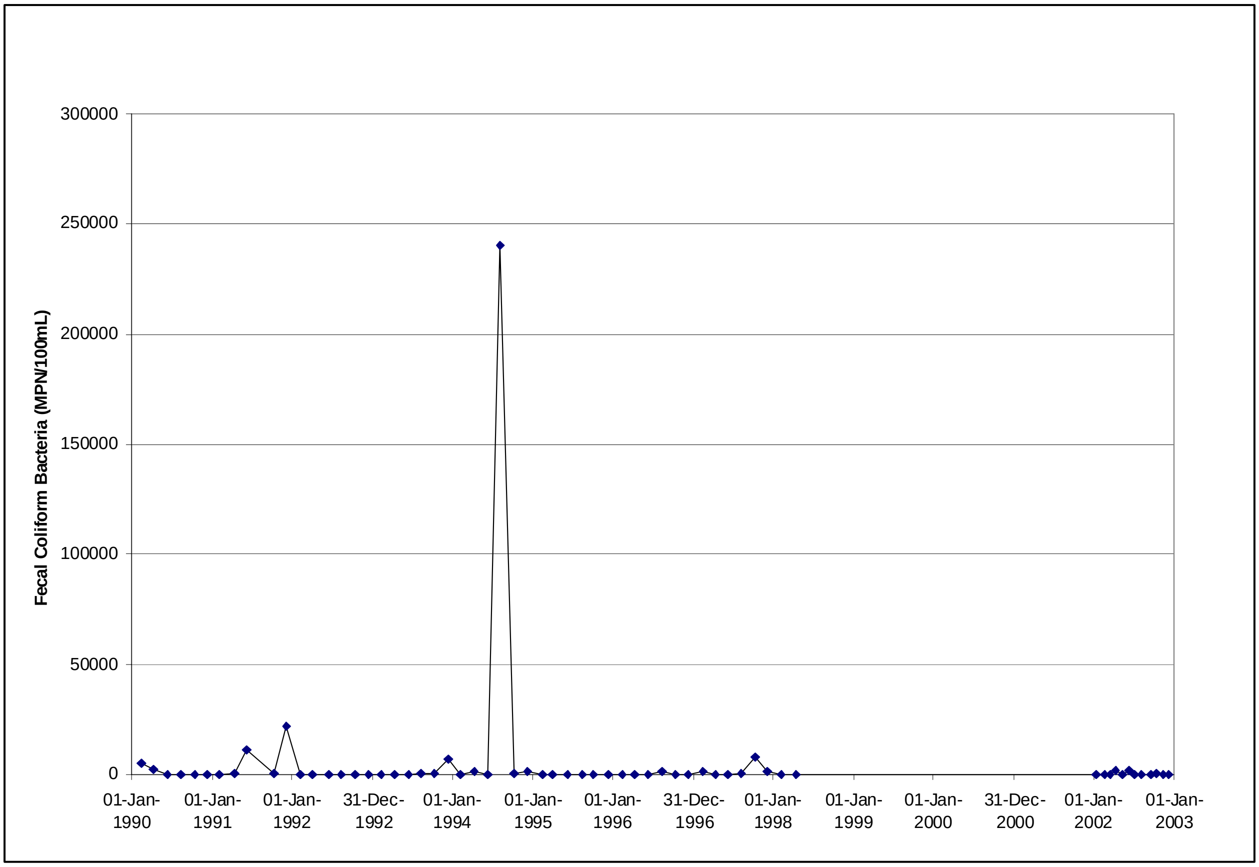

Figure C-5. Fecal coliform bacteria observations at Flat River (subsegment 100406) east of Taylortown, Louisiana (station 272).

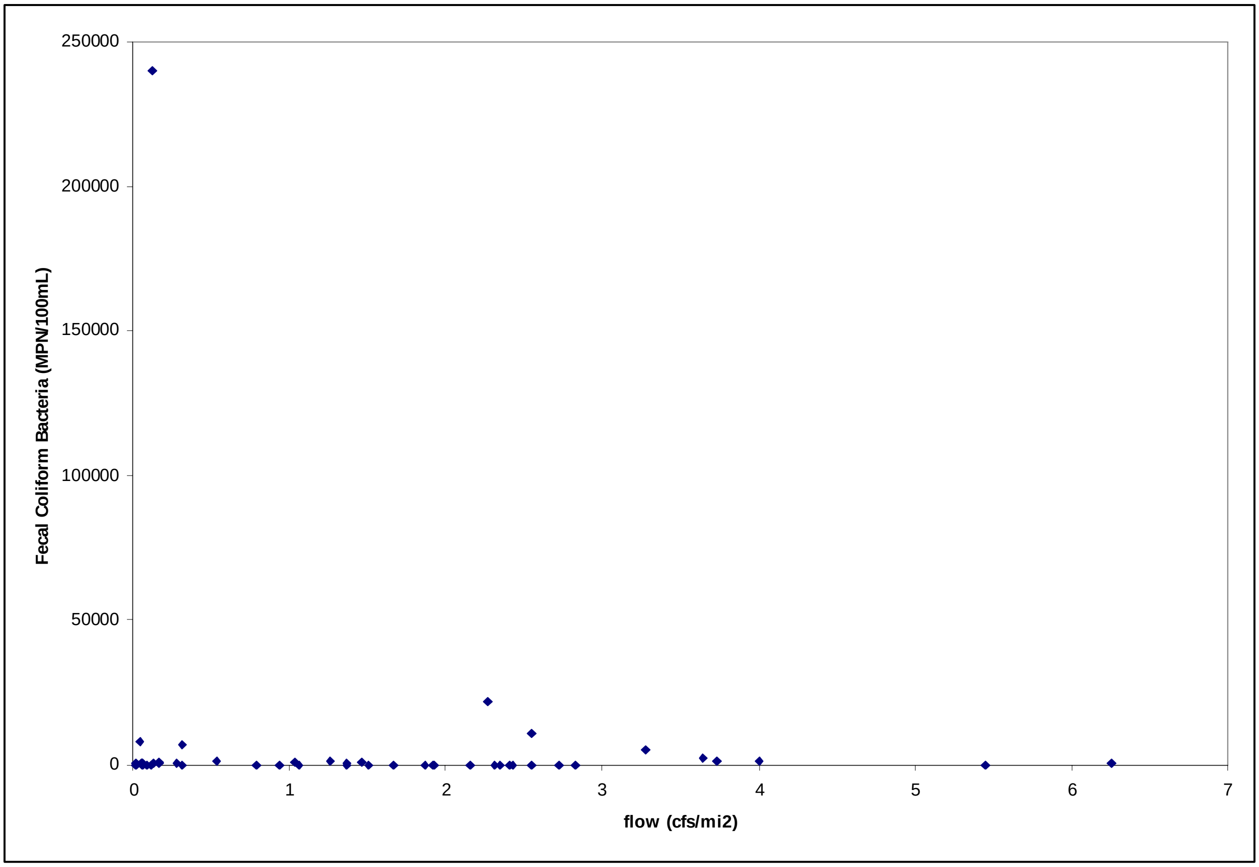

Figure C-6. Fecal coliform bacteria versus flow at Flat River (subsegment 100406) east of Taylortown, Louisiana (station 272).

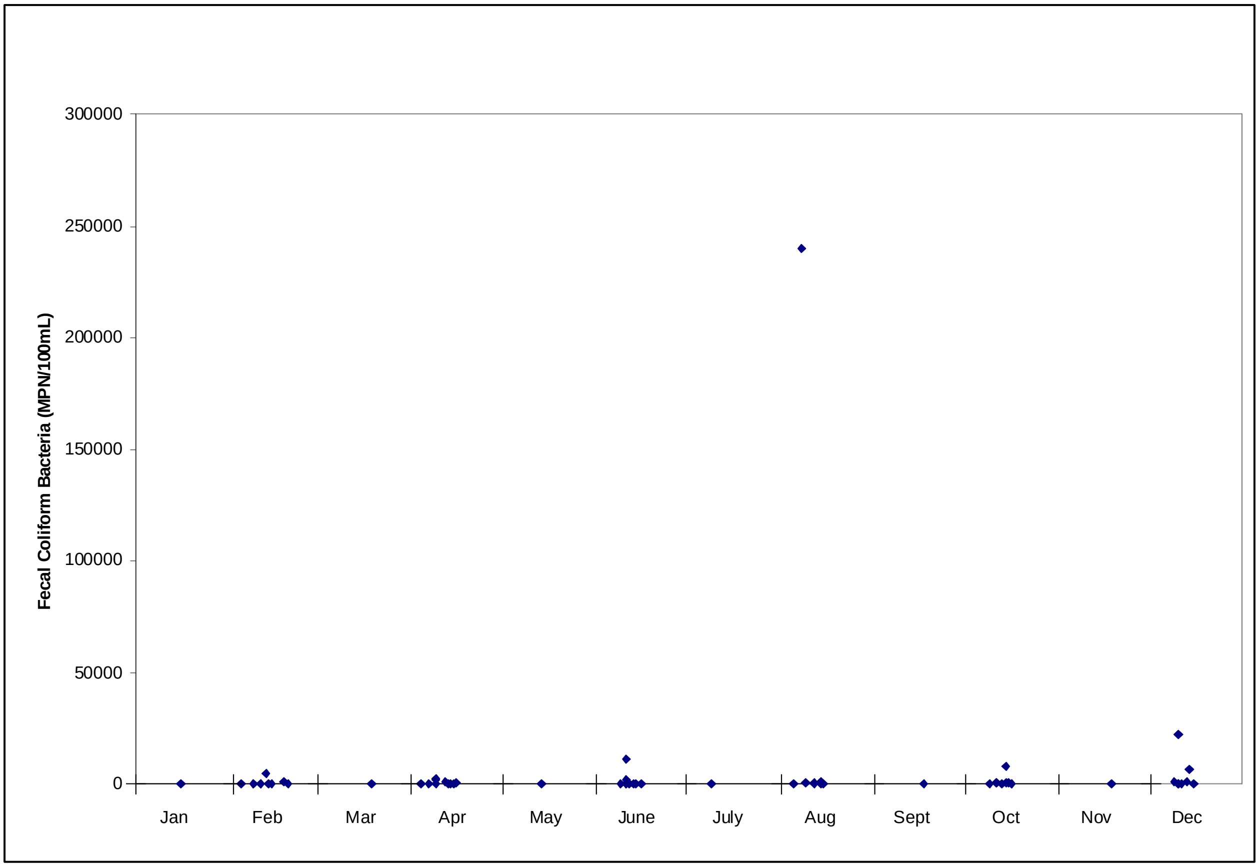

Figure C-7. Fecal coliform bacteria observations by season at Flat River (subsegment 100406) east of Taylortown, Louisiana (station 272).

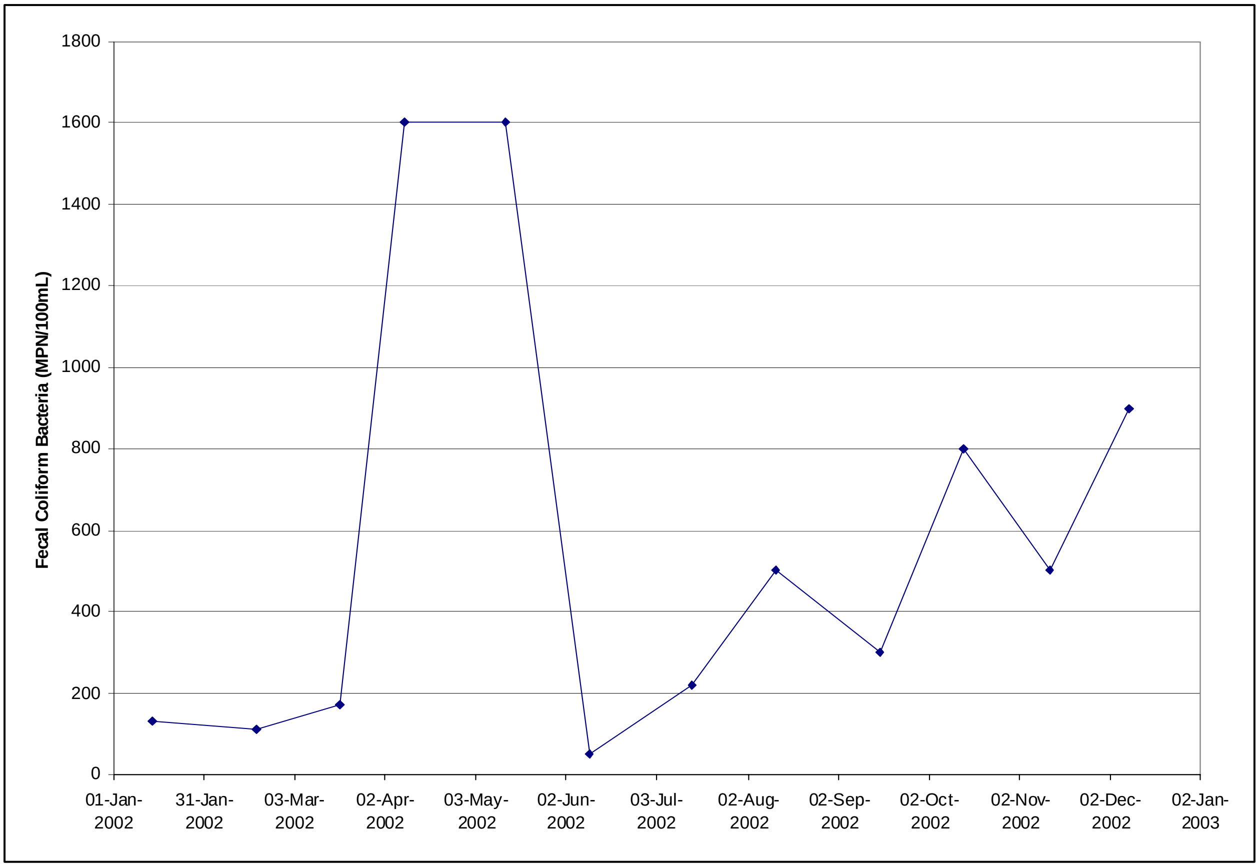

Figure C-8. Fecal coliform bacteria observations at Castor Creek (subsegment 100707) at Highway 507, southwest of Castor, Louisiana (station 1189).

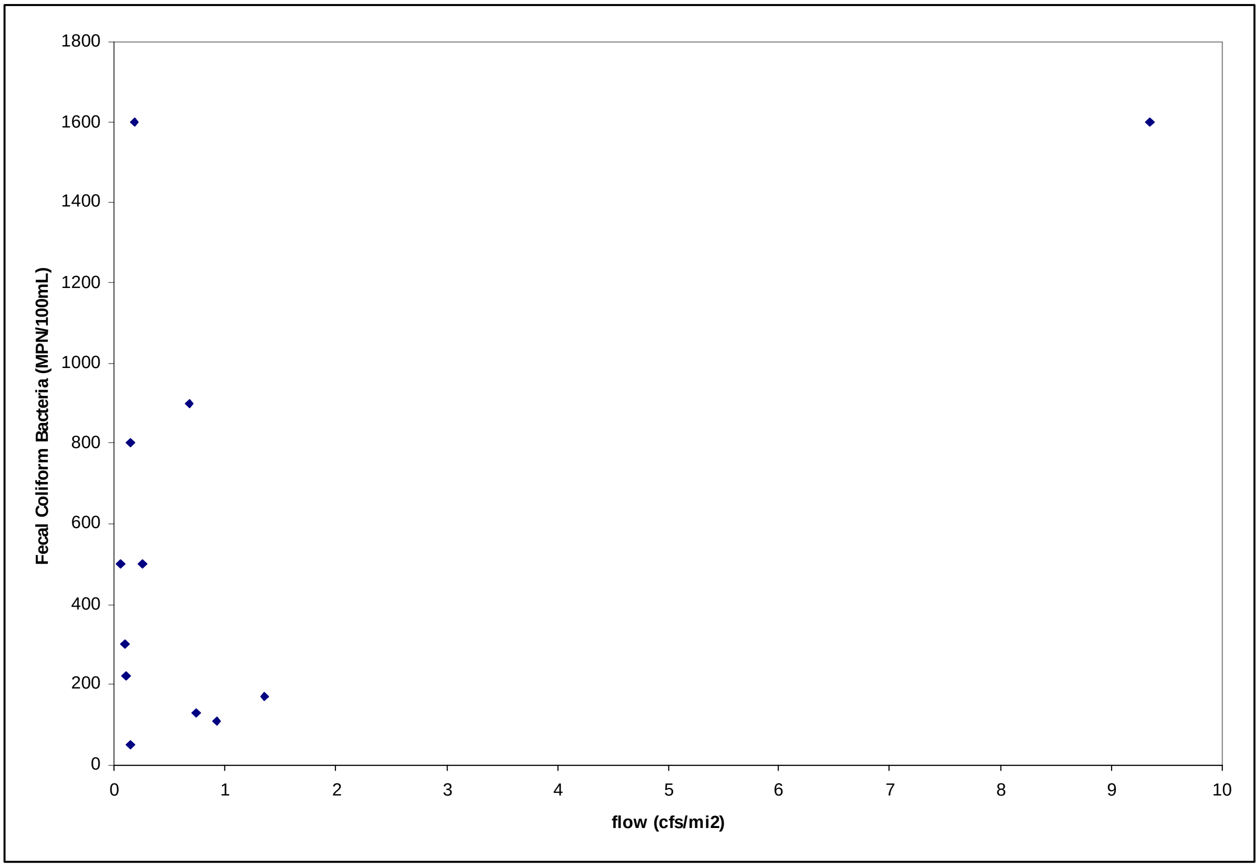

Figure C-9. Fecal coliform bacteria versus flow at Castor Creek (subsegment 100707) at Highway 507, southwest of Castor, Louisiana (station 1189).

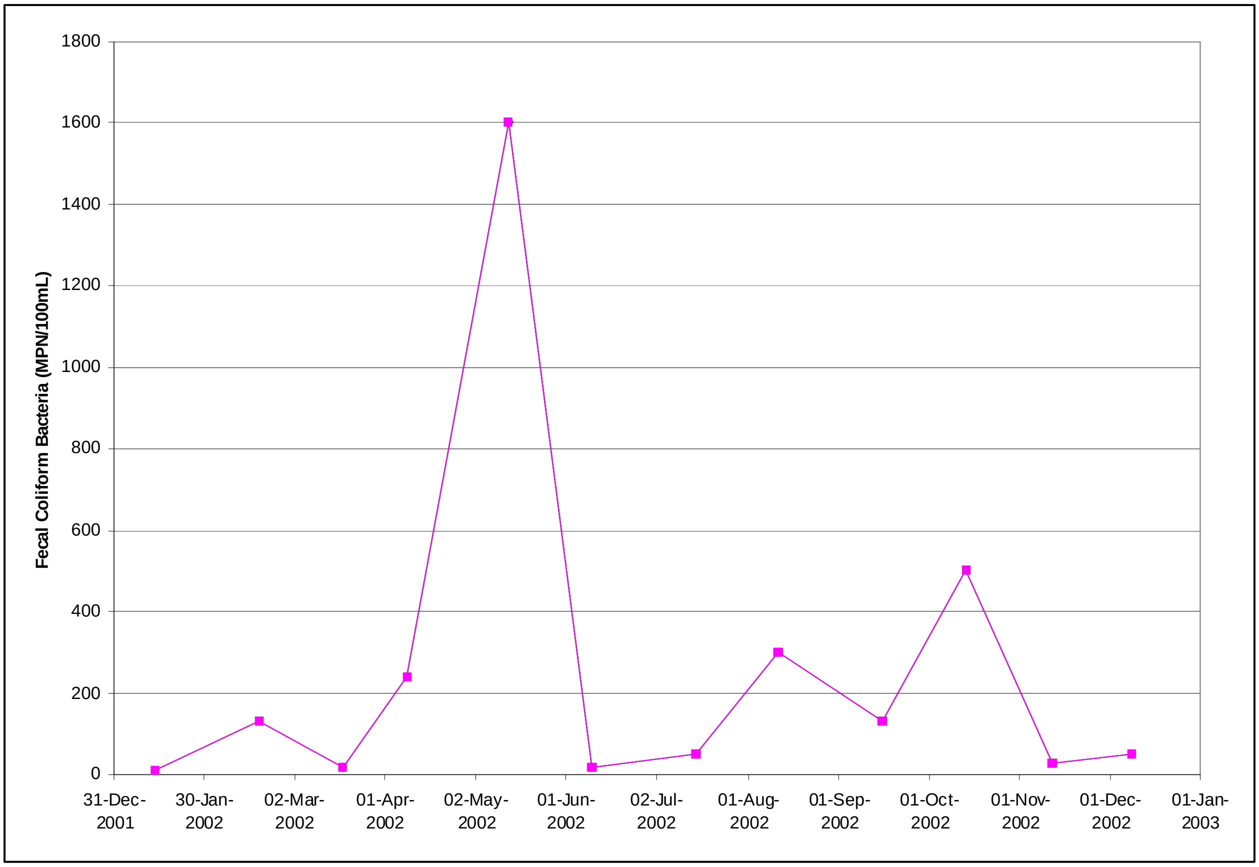

Figure C-10. Fecal coliform bacteria observations at Grand Bayou (subsegment 100709) at Highway 507, north of Fairview Alpha, Louisiana (station 1190).

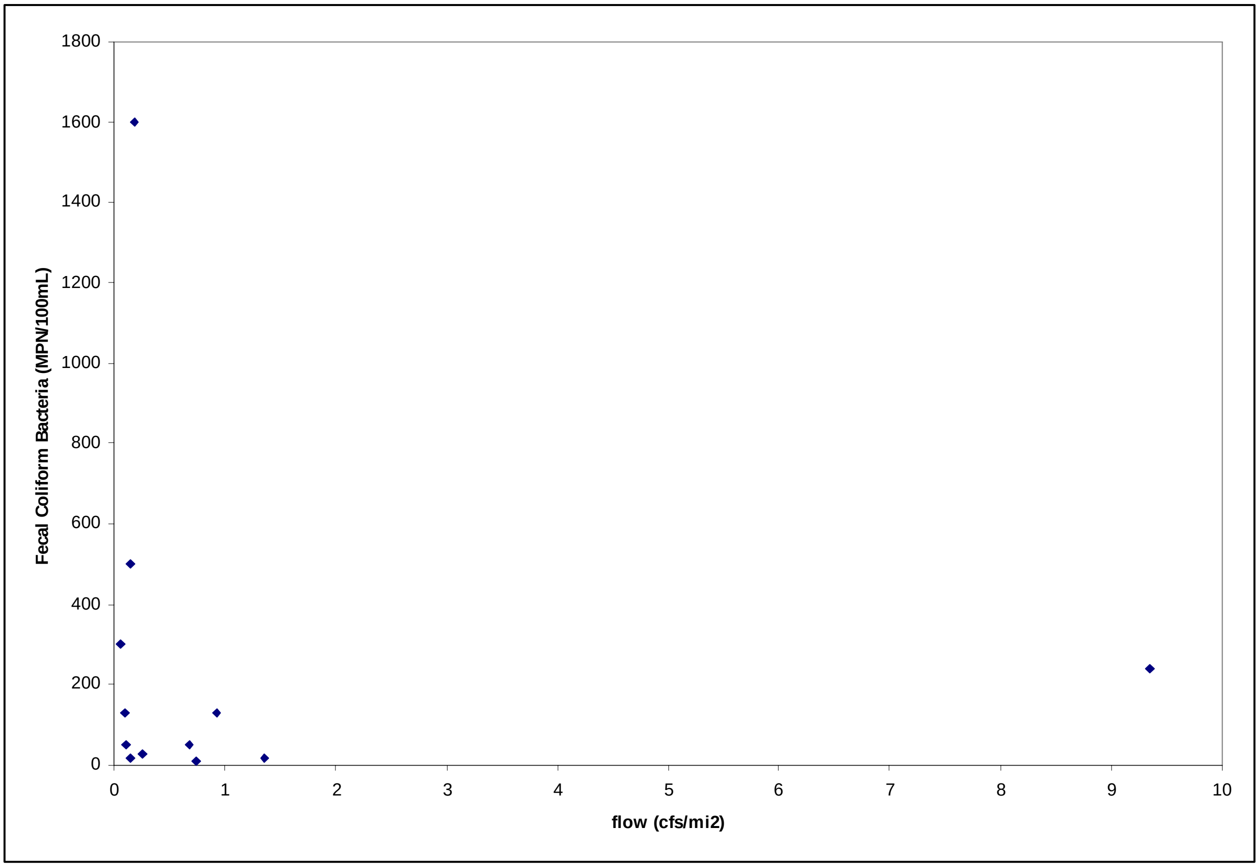

Figure C-11. Fecal coliform bacteria versus flow at Grand Bayou (subsegment 100709) at Highway 507, north of Fairview Alpha, Louisiana (station 1190).

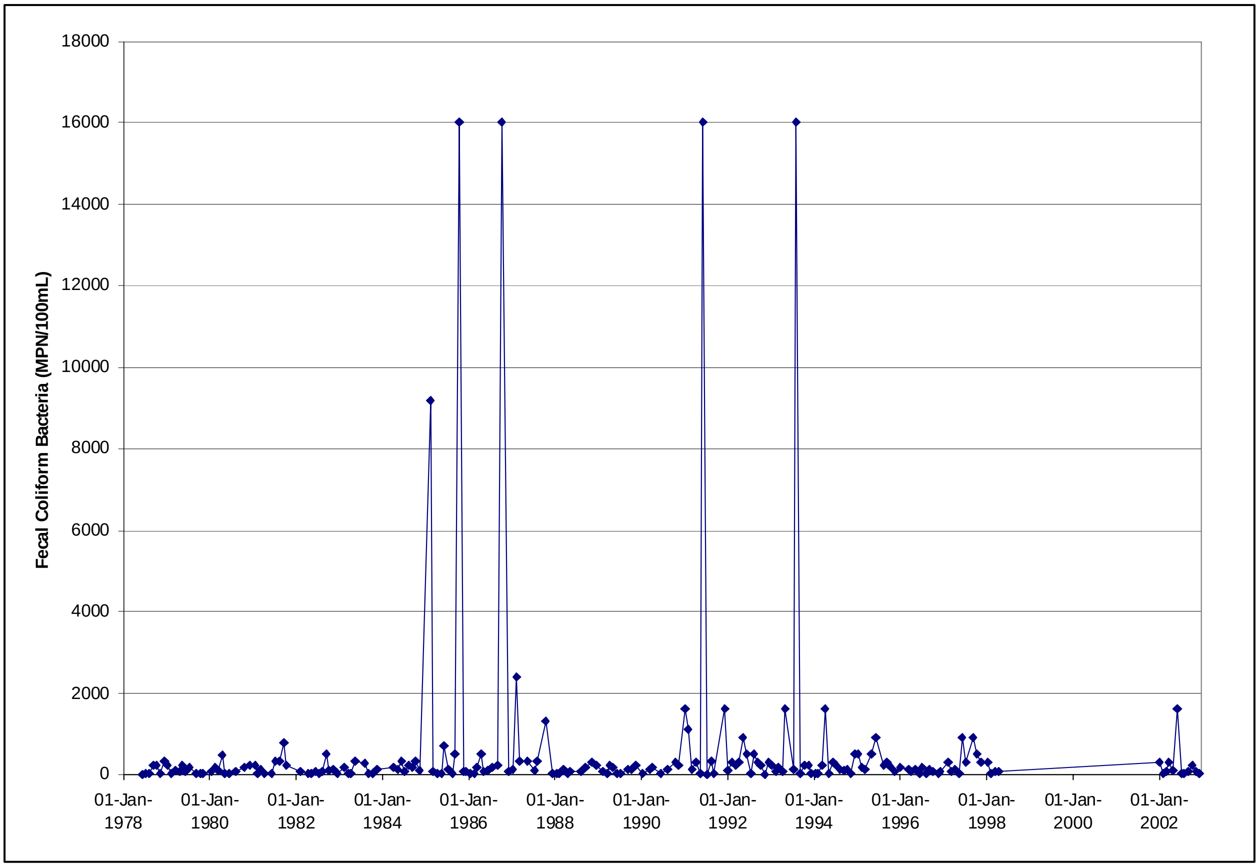

Figure C-12. Fecal coliform bacteria observations at Saline Bayou (subsegment 100801) near Goldonna, Louisiana (station 75).

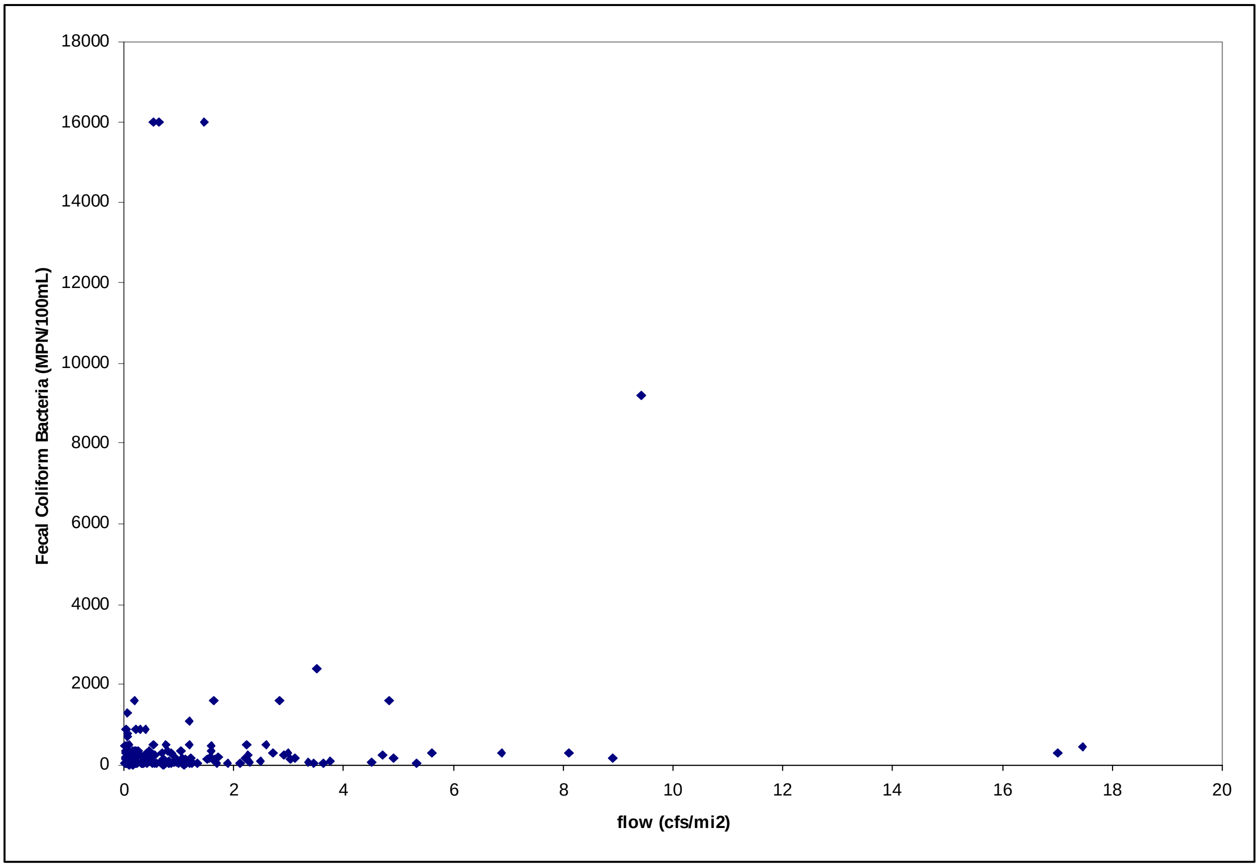

Figure C-13. Fecal coliform bacteria versus flow at Saline Bayou (subsegment 100801) near Goldonna, Louisiana (station 75).

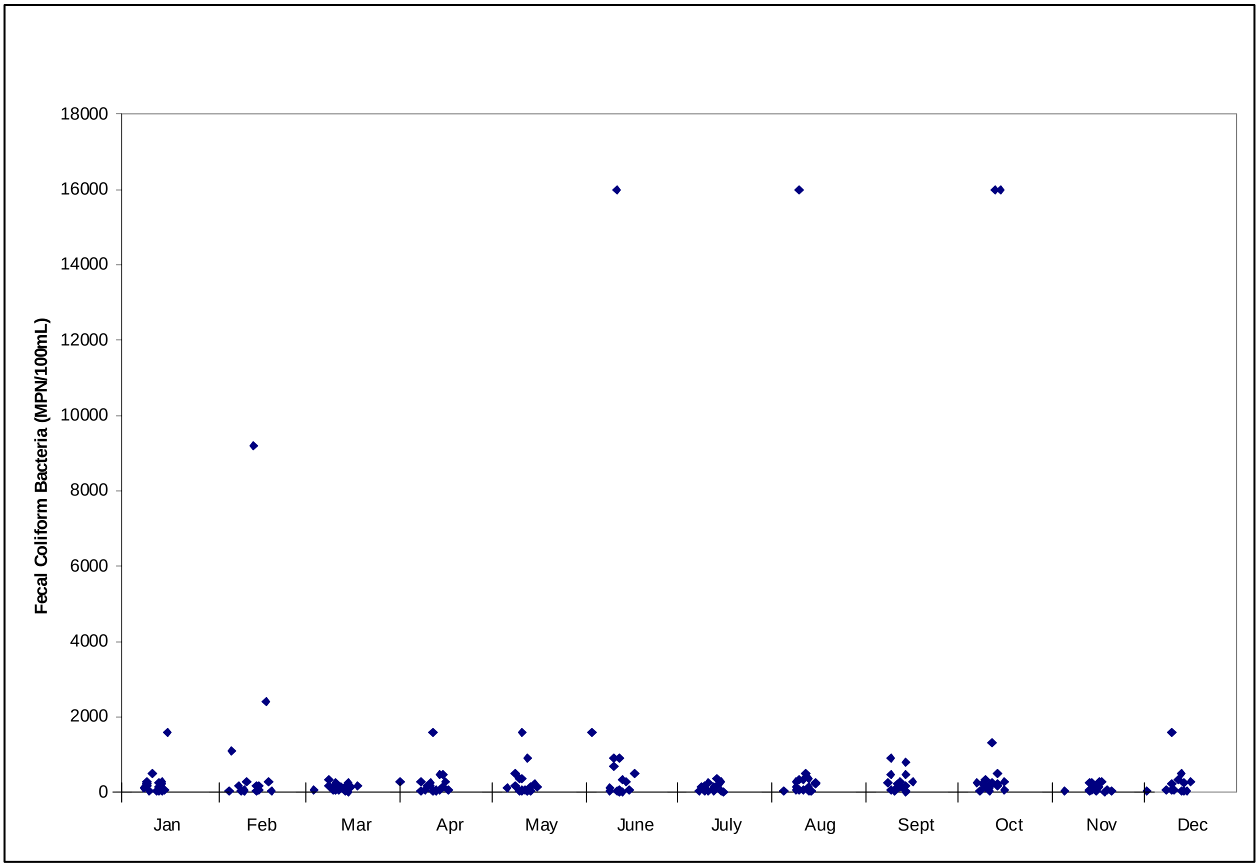

Figure C-14. Fecal coliform bacteria observations by season at Saline Bayou (subsegment 100801) near Goldonna, Louisiana (station 75).

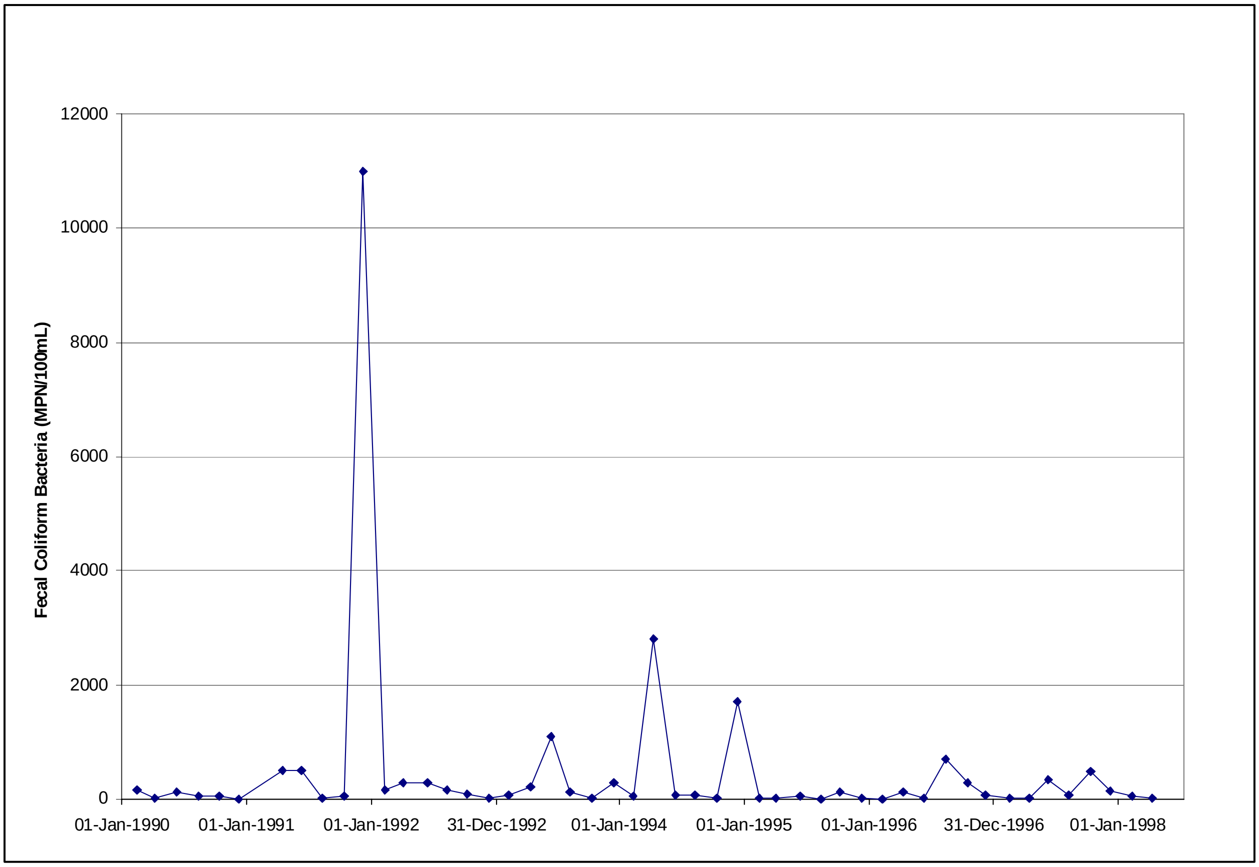

Figure C-15. Fecal coliform bacteria observations at Saline Bayou (subsegment 100801) east of Bienville, Louisiana (station 284).

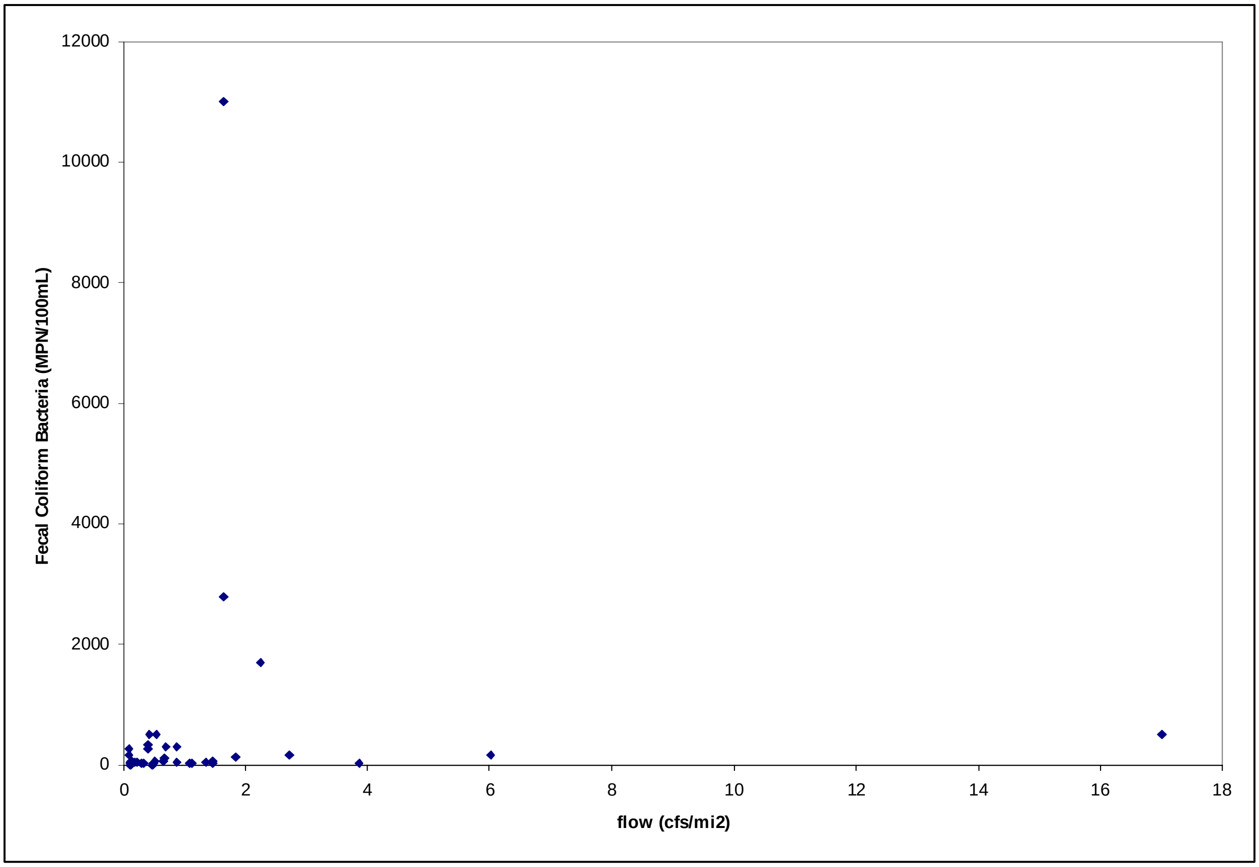

Figure C-16. Fecal coliform bacteria versus flow at Saline Bayou (subsegment 100801) east of Bienville, Louisiana (station 284).

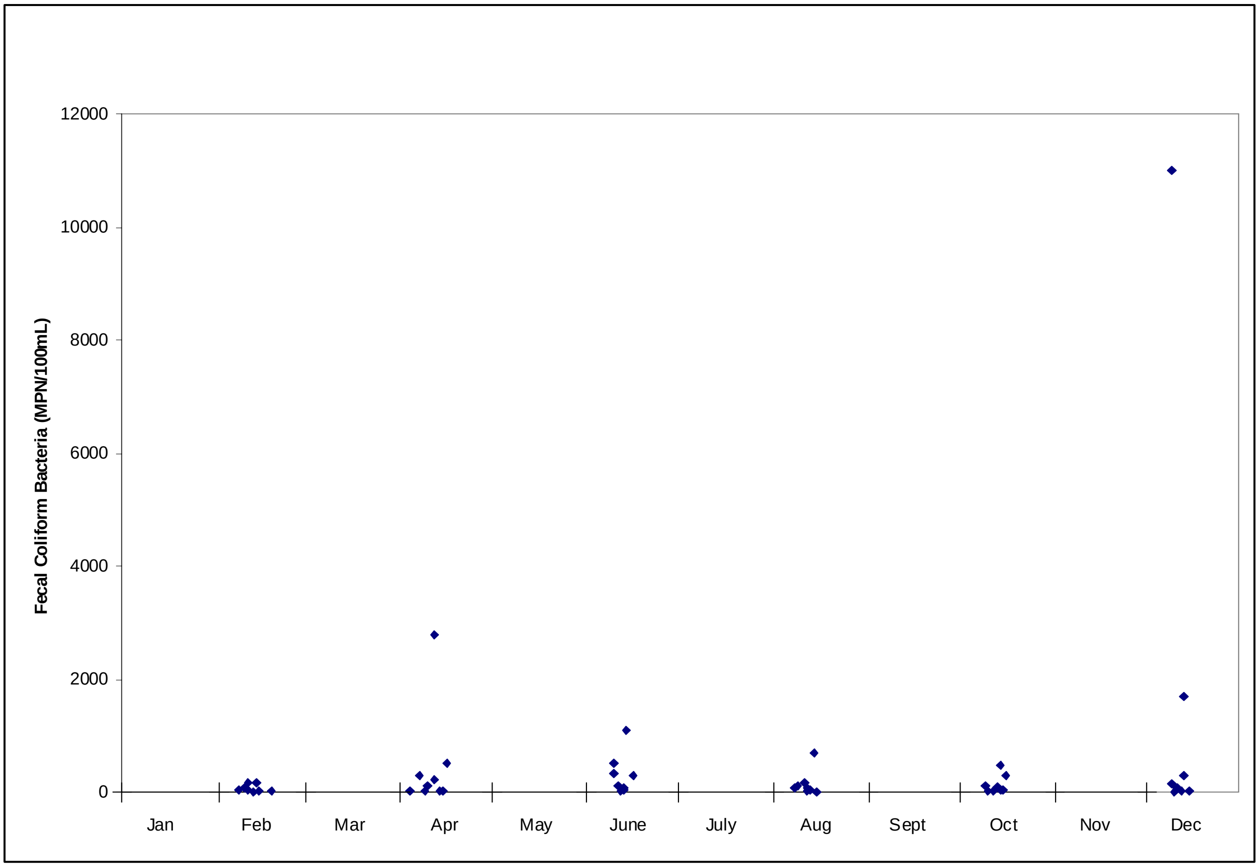

Figure C-17. Fecal coliform bacteria observations by season at Saline Bayou (subsegment 100801) east of Bienville, Louisiana (station 284).

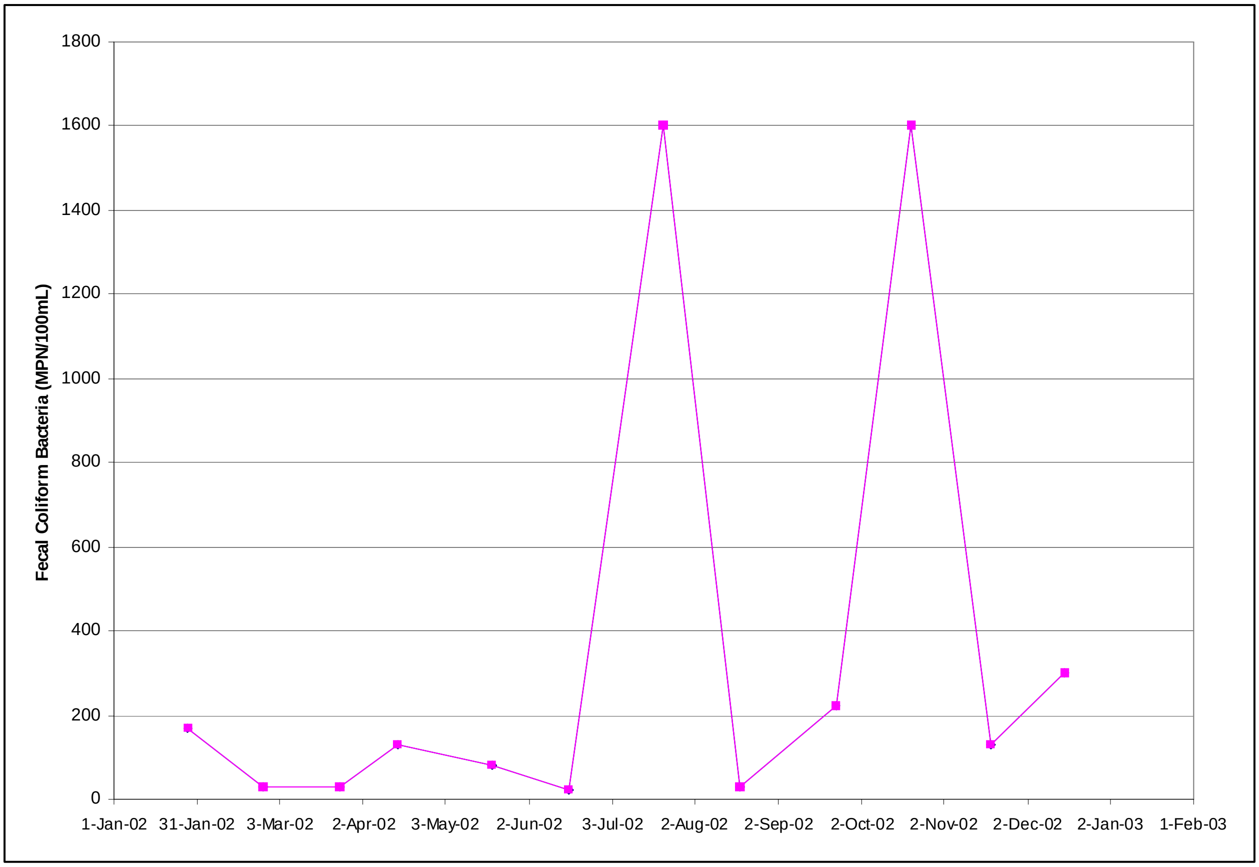

Figure C-18. Fecal coliform bacteria observations at Nantachie Creek (subsegment 100901) east of Montgomery, Louisiana (station 1215).

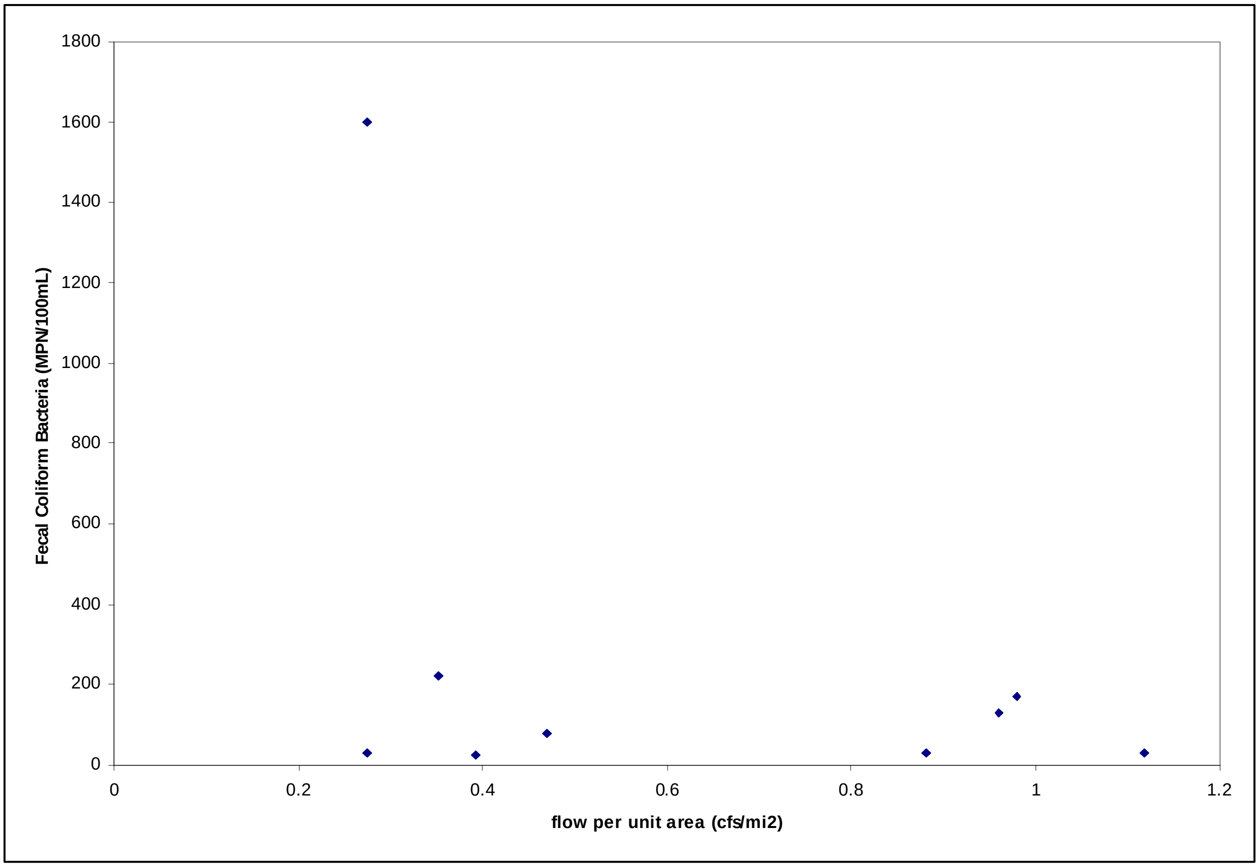

Figure C-19. Fecal coliform bacteria versus flow at Nantachie Creek (subsegment 100901) east of Montgomery, Louisiana (station 1215).

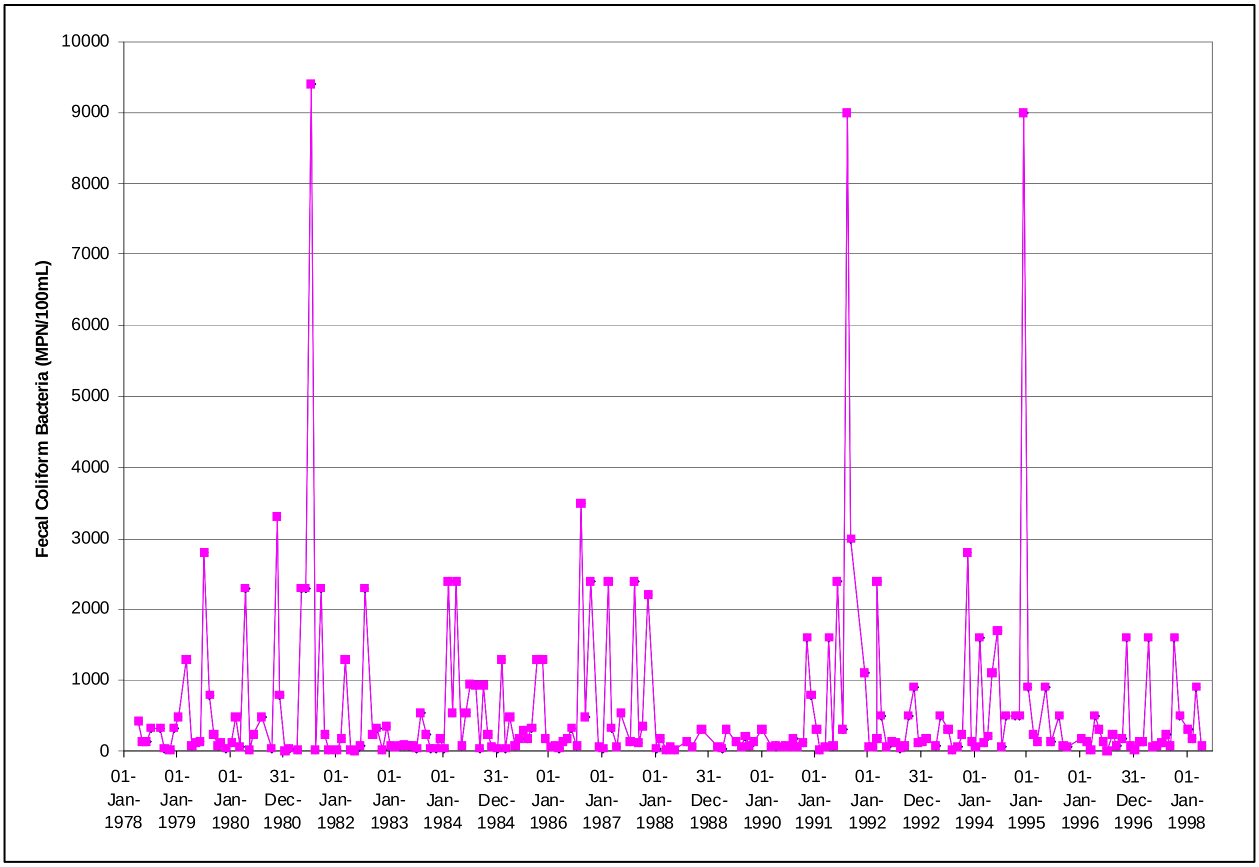

Figure C-20. Fecal coliform bacteria observations at Kisatchie Bayou (subsegment 101103) near Lotus, Louisiana (station 42).

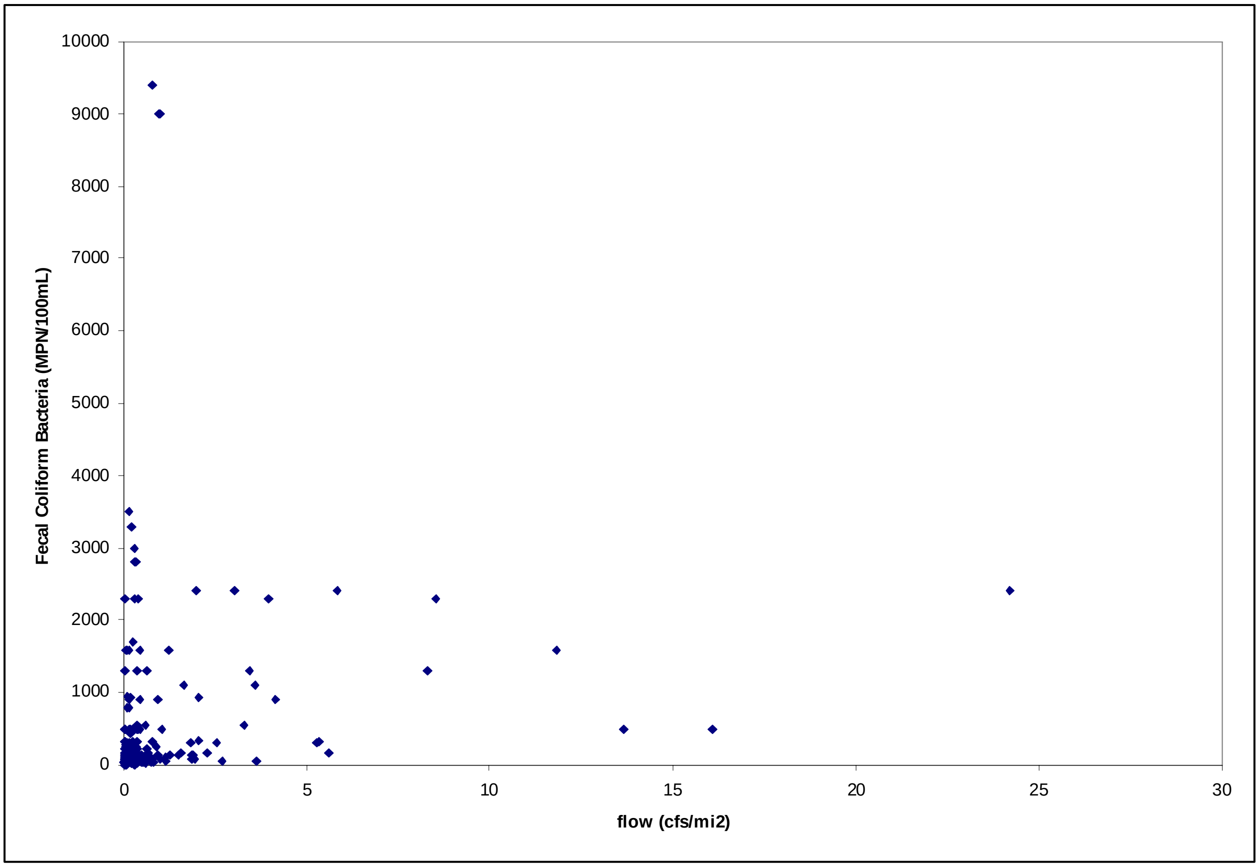

Figure C-21. Fecal coliform bacteria versus flow at Kisatchie Bayou (subsegment 101103) near Lotus, Louisiana (station 42).

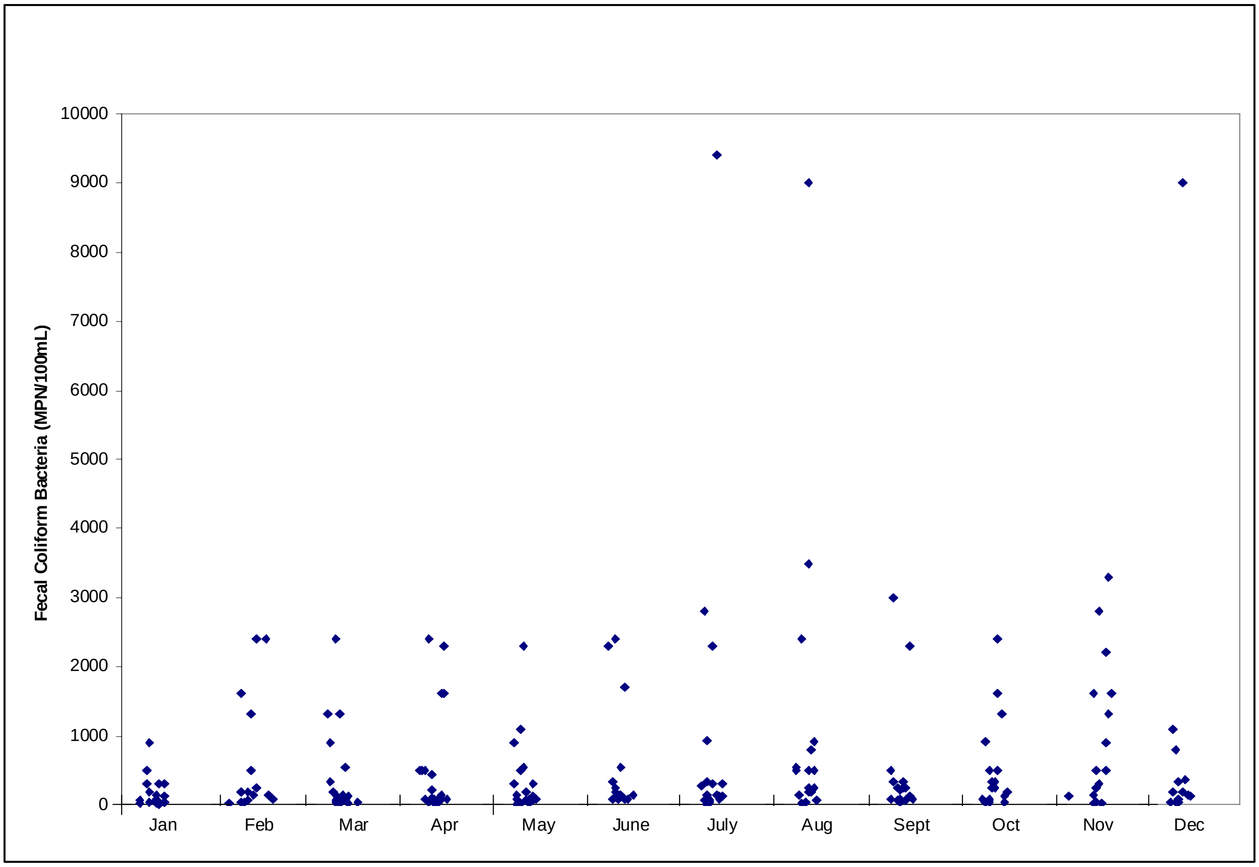

Figure C-22. Fecal coliform bacteria observations by season at Kisatchie Bayou (subsegment 101103) near Lotus, Louisiana (station 42).

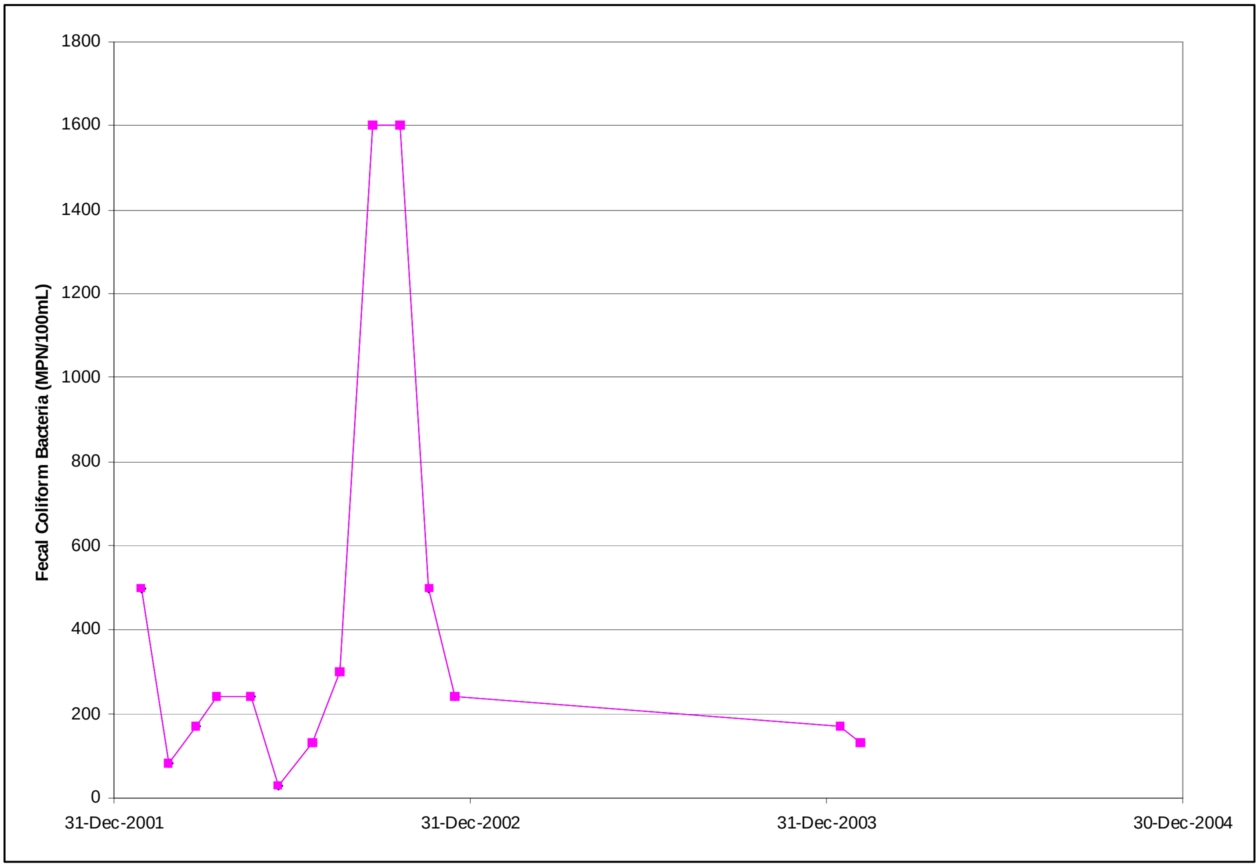

Figure C-23. Fecal coliform bacteria observations at Kisatchie Bayou (subsegment 101103) south of Cypress, Louisiana (station 1218).

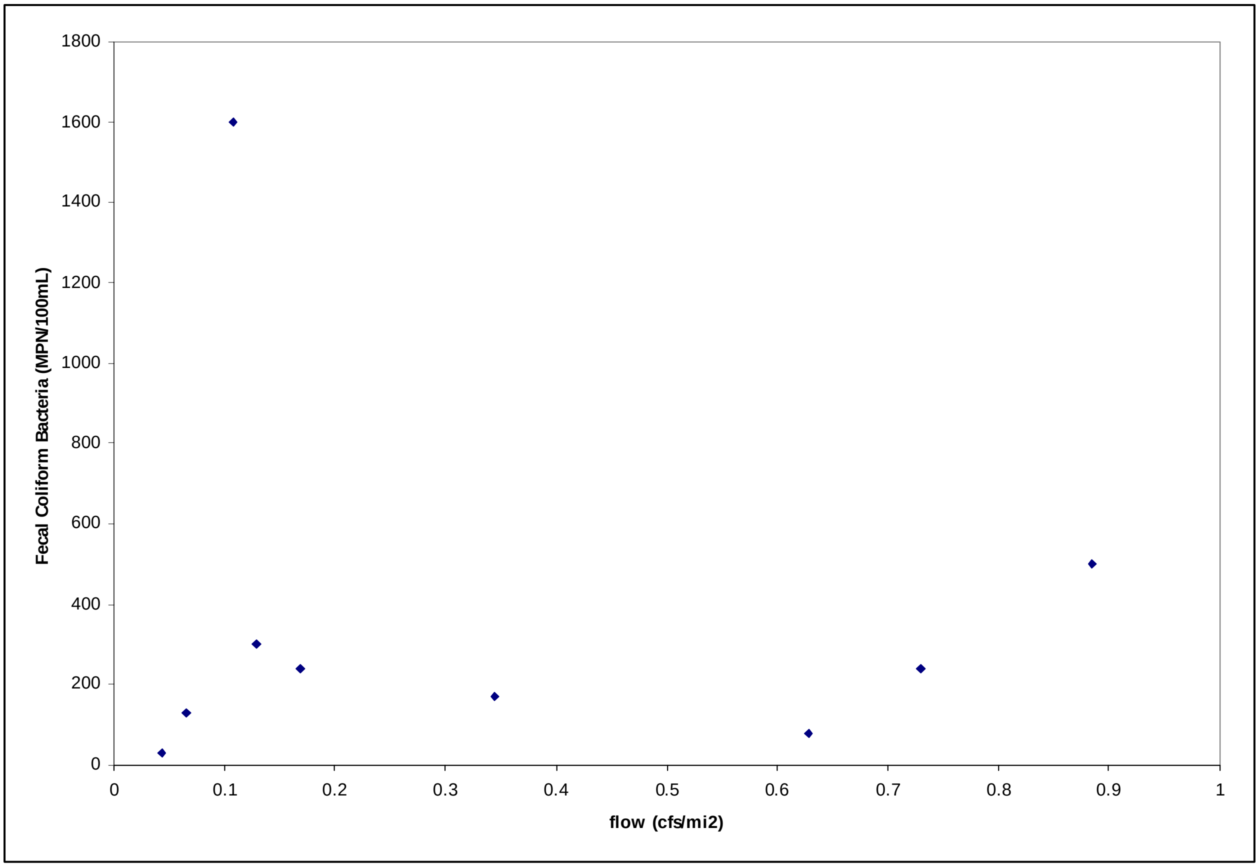

Figure C-24. Fecal coliform bacteria versus flow at Kisatchie Bayou (subsegment 101103) south of Cypress, Louisiana (station 1218).

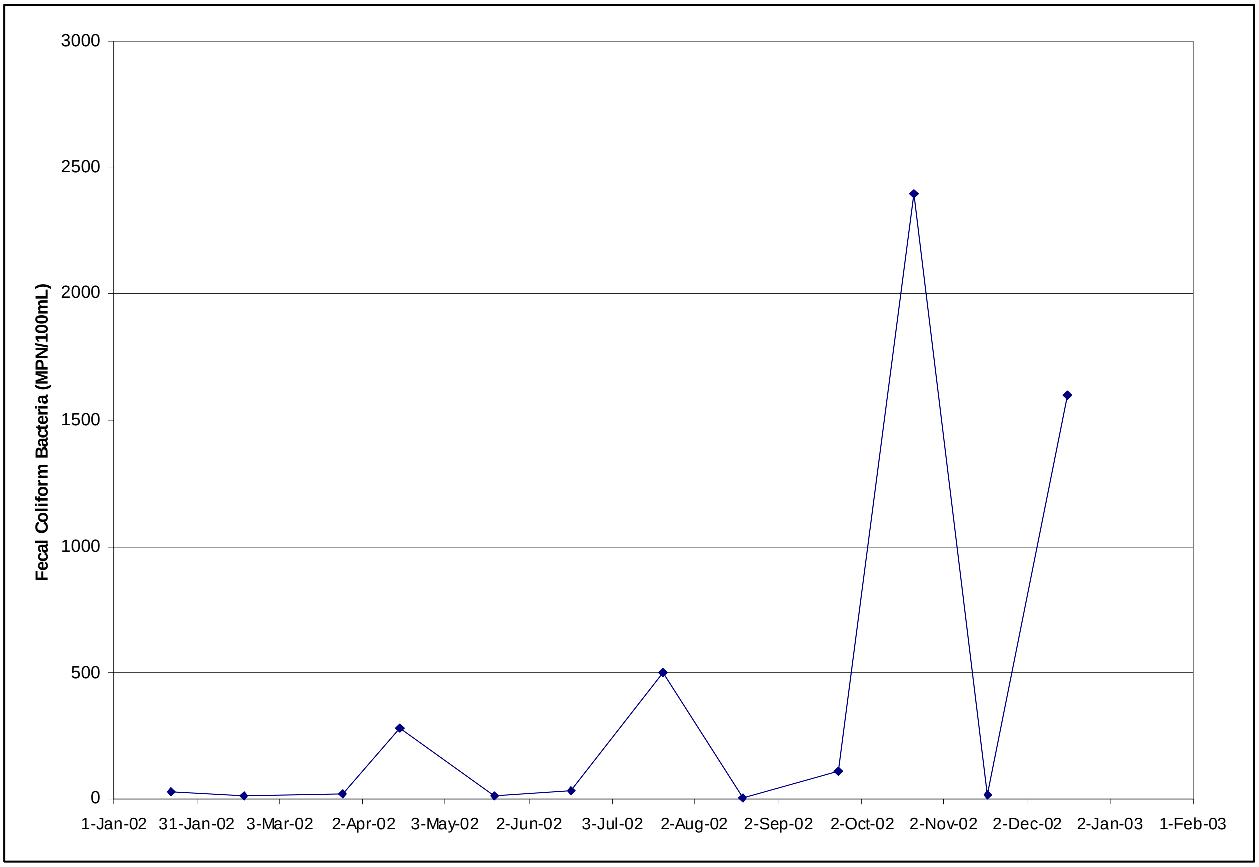

Figure C-25. Fecal coliform bacteria observations at Rigolette Bayou (subsegment 101301) northwest of Pineville, Louisiana (station 1220).

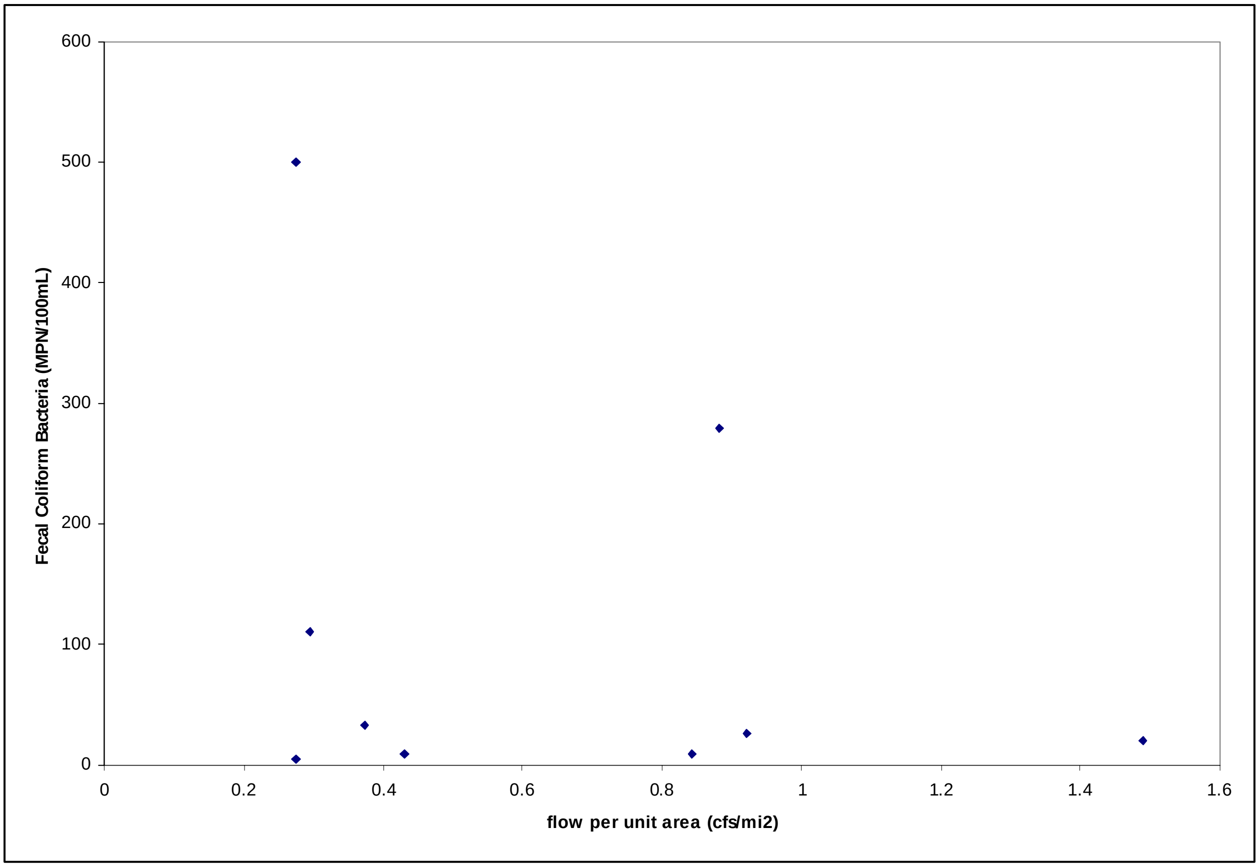

Figure C-26. Fecal coliform bacteria versus flow at Rigolette Bayou (subsegment 101301) northwest of Pineville, Louisiana (station 1220).

Appendix D
Chloride Figures for Red River Basin

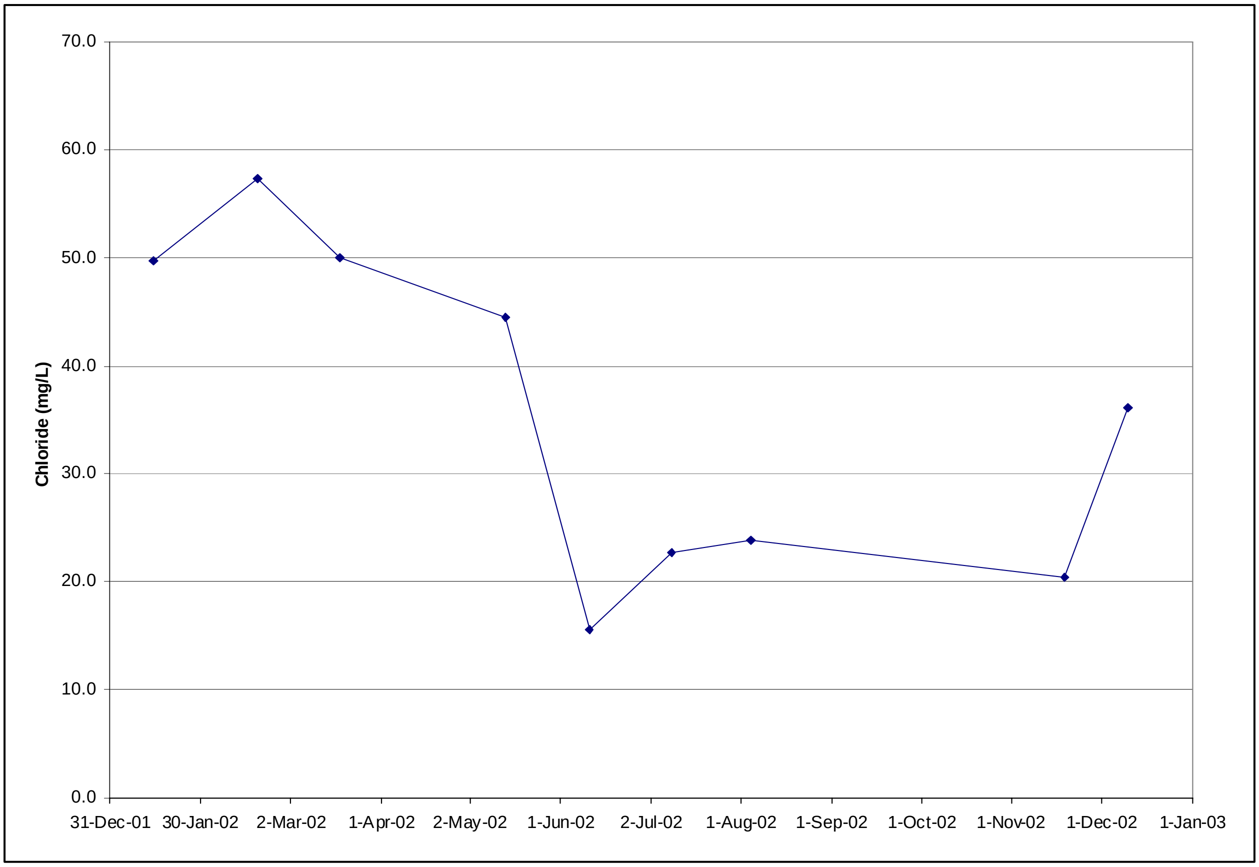

Figure D-1. Chloride observations at unnamed tributary of Grand Bayou (subsegment 100710) near Hall Summit, Louisiana (station 1195).

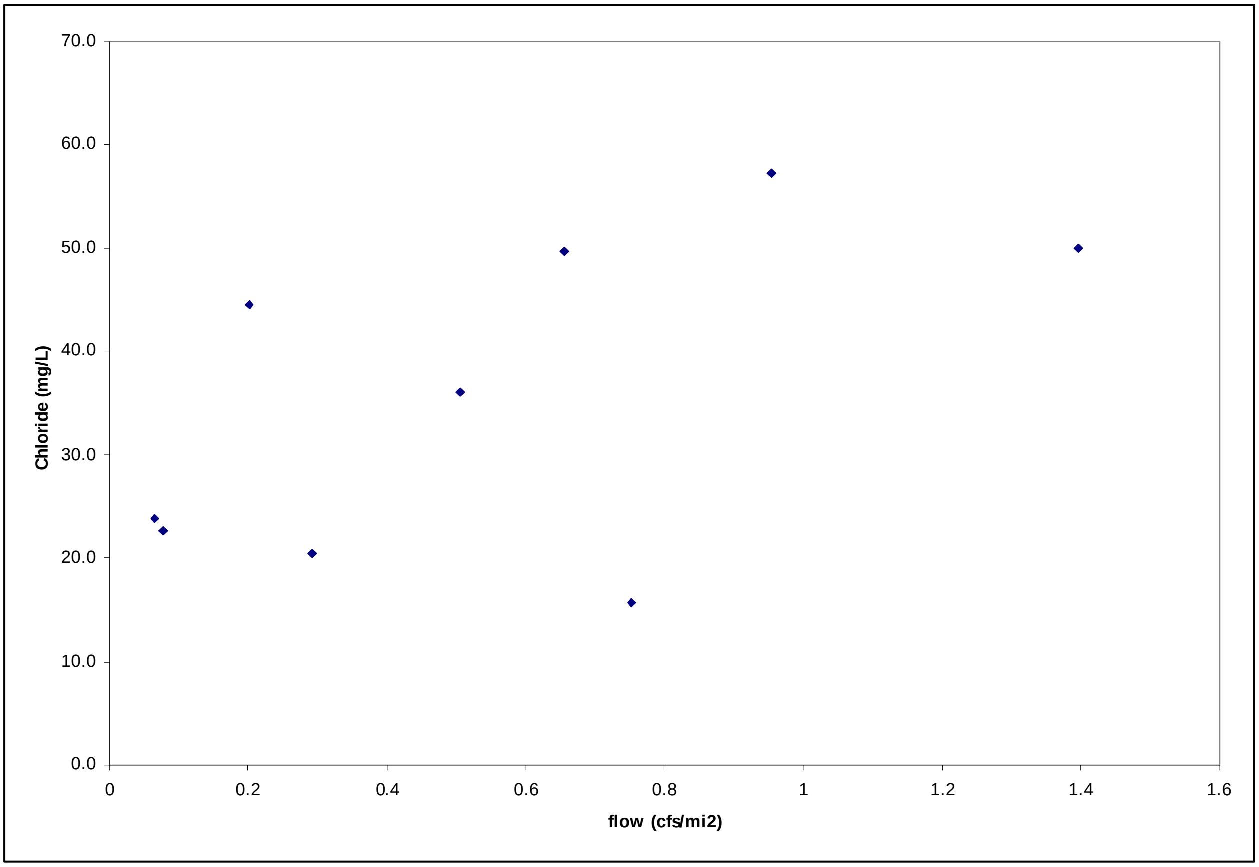

Figure D-2. Chloride versus flow at unnamed tributary of Grand Bayou (subsegment 100710) near Hall Summit, Louisiana (station 1195).

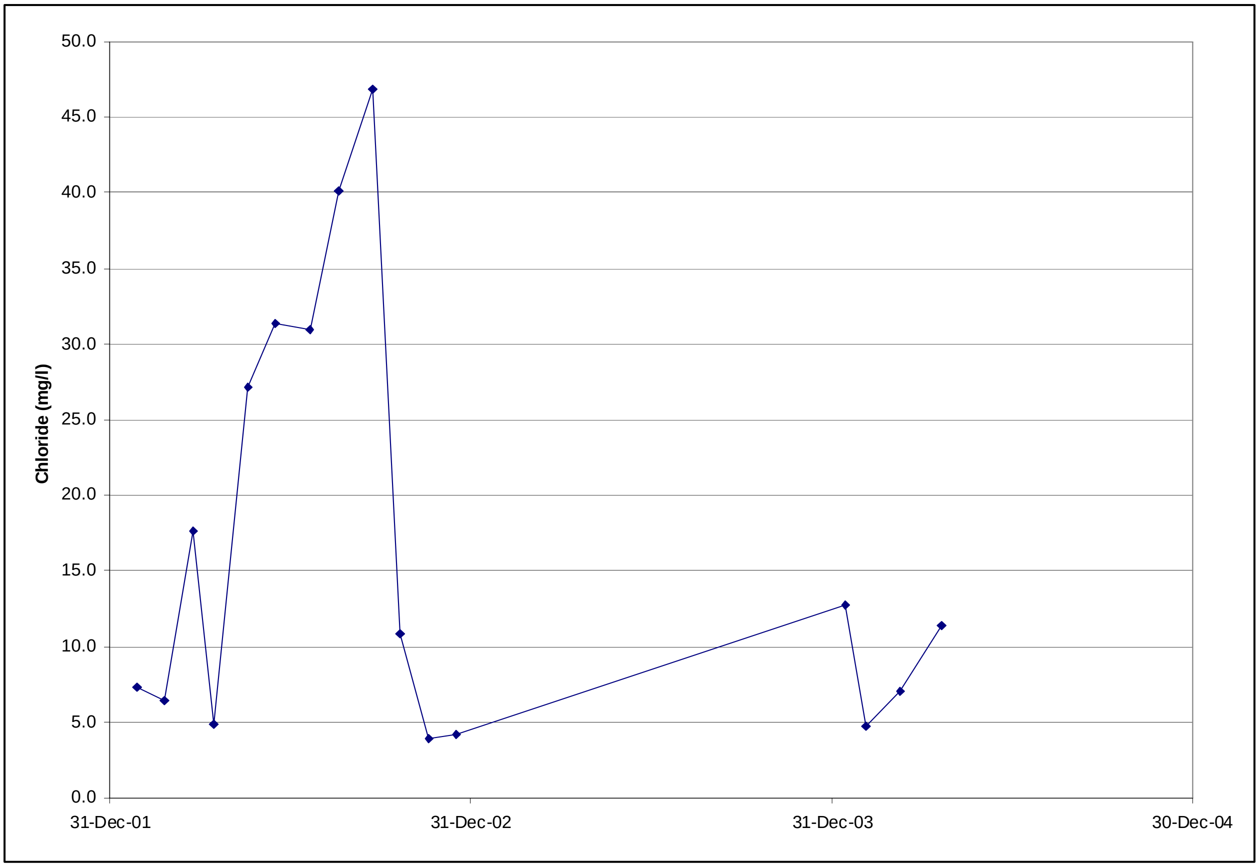

Figure D-3. Chloride observations at Cane River (subsegment 101101) west of Colfax, Louisiana (station 1217).

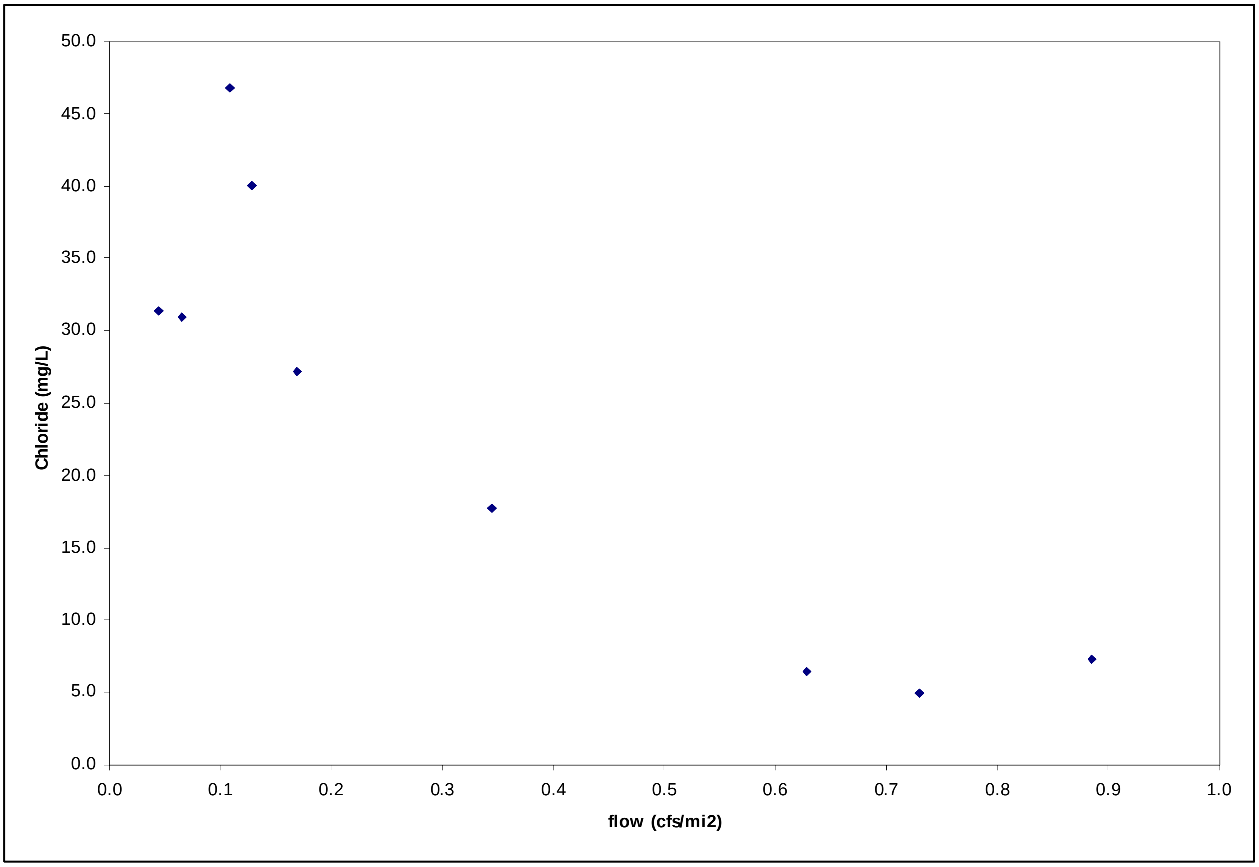

Figure D-4. Chloride versus flow at Cane River (subsegment 101101) west of Colfax, Louisiana (station 1217).

Appendix E
Sulfate Figures for the Red River Basin

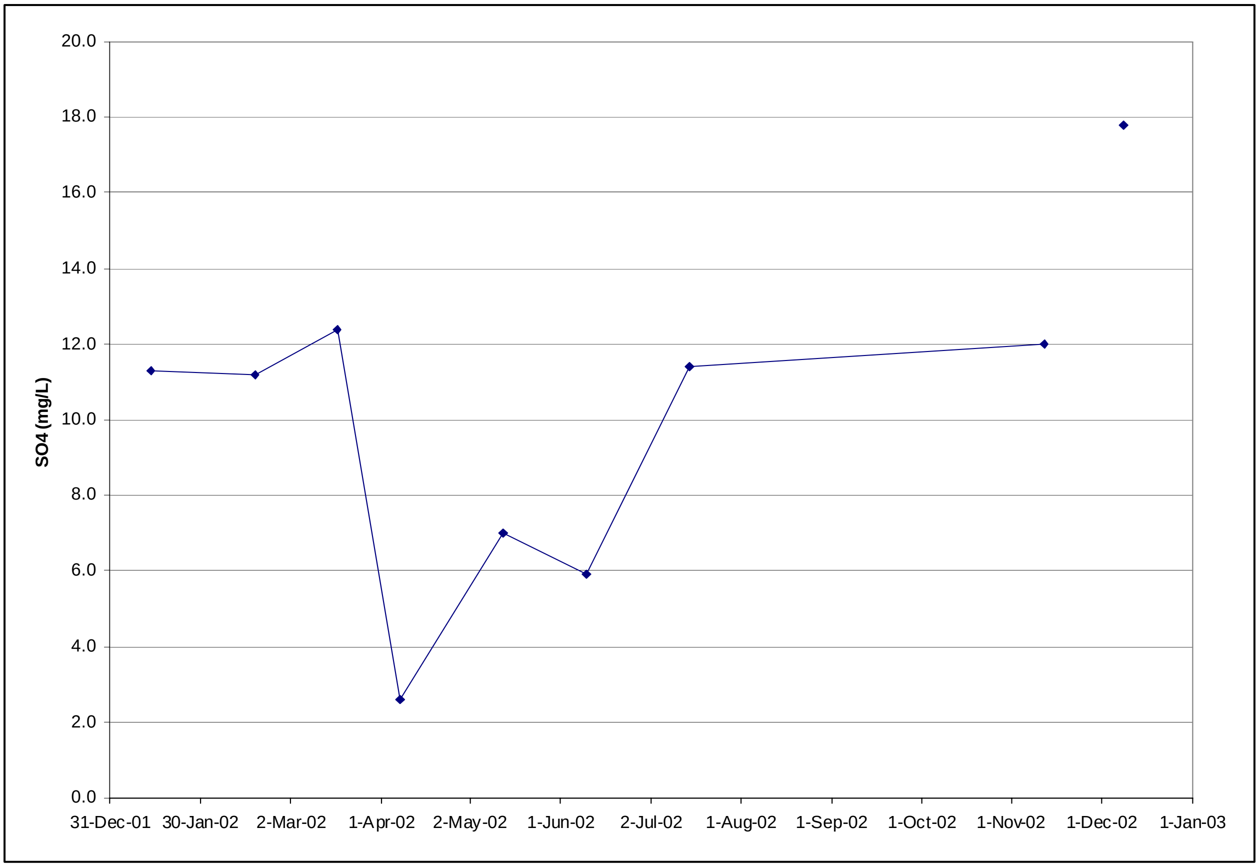

Figure E-1. Sulfate observations at unnamed tributary of Castor Creek (subsegment 100708) near Castor, Louisiana (station 1194).

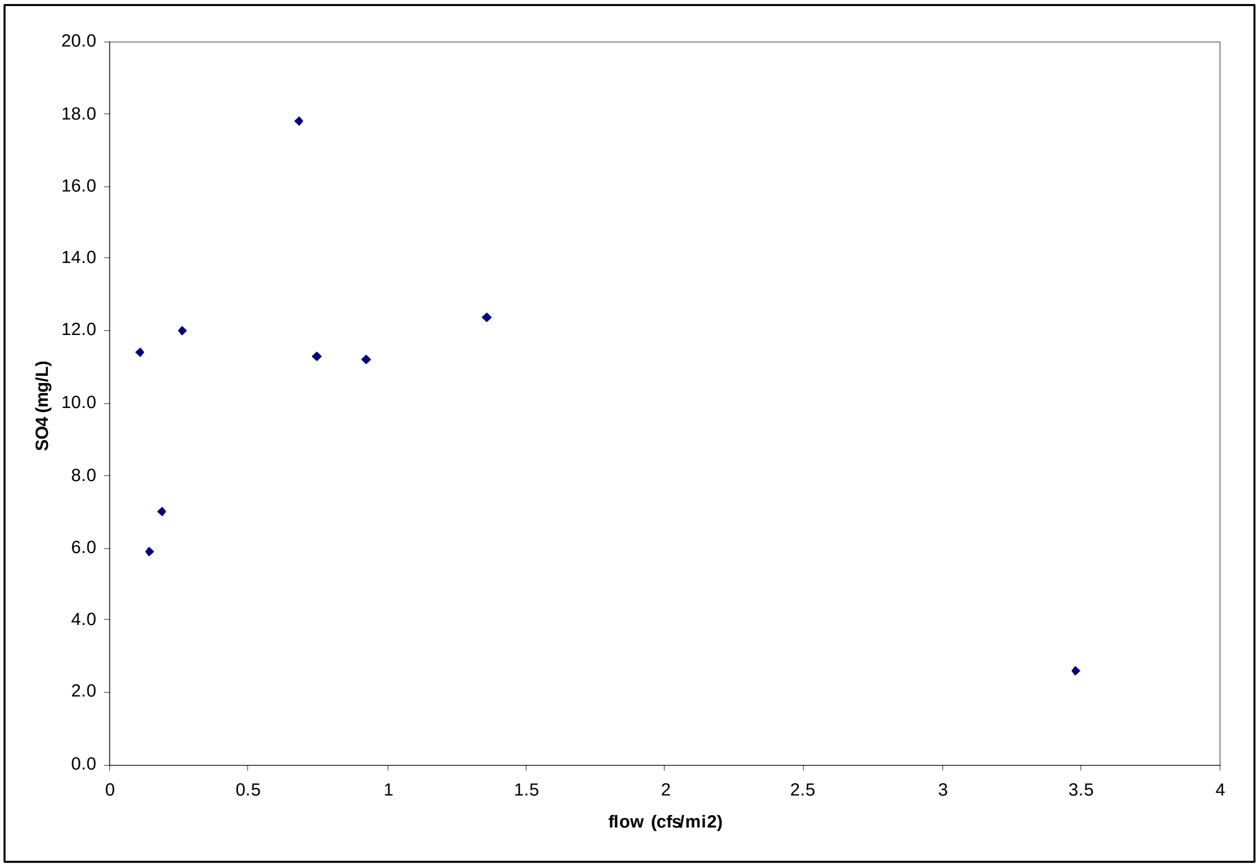

Figure E-2. Sulfate versus flow at unnamed tributary of Castor Creek (subsegment 100708) near Castor, Louisiana (station 1194).

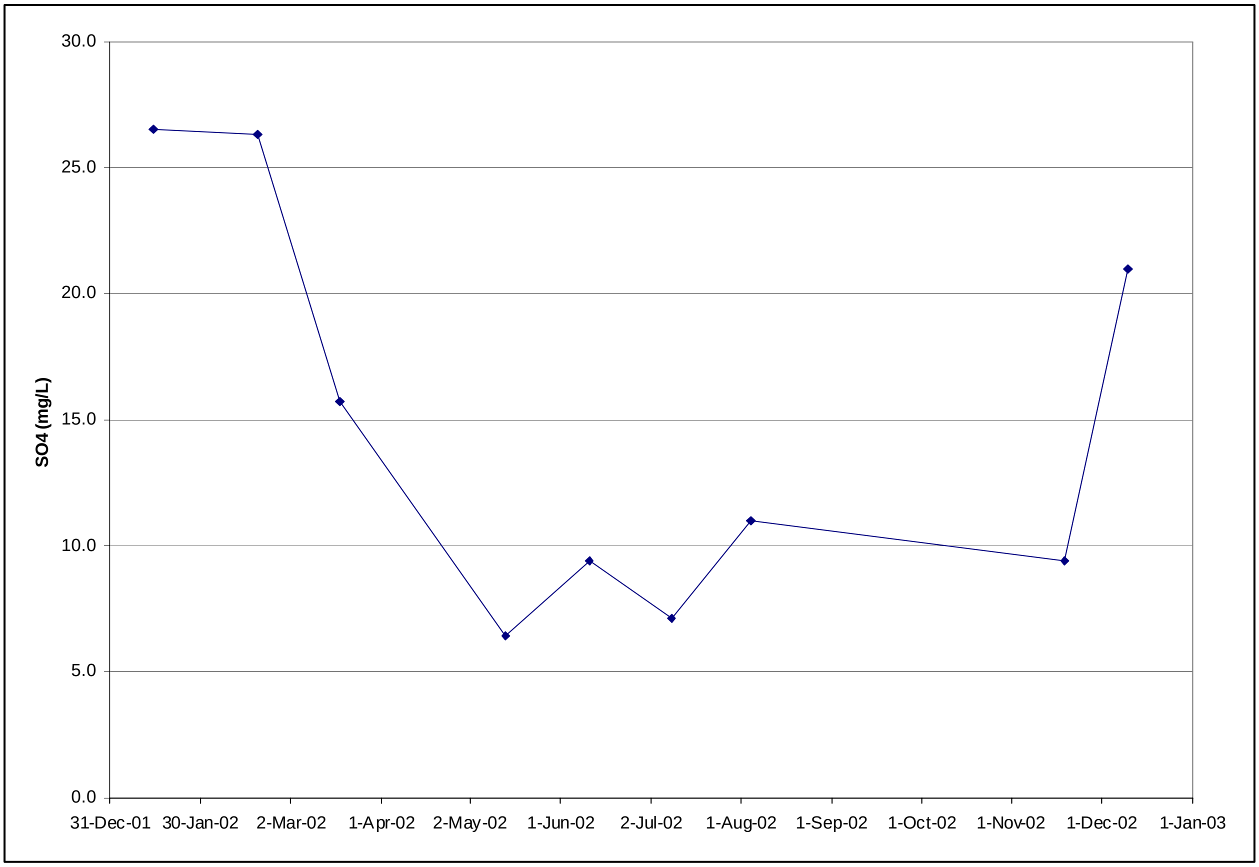

Figure E-3. Sulfate observations at unnamed tributary of Grand Bayou (subsegment 100710) near Hall Summit, Louisiana (station 1195).

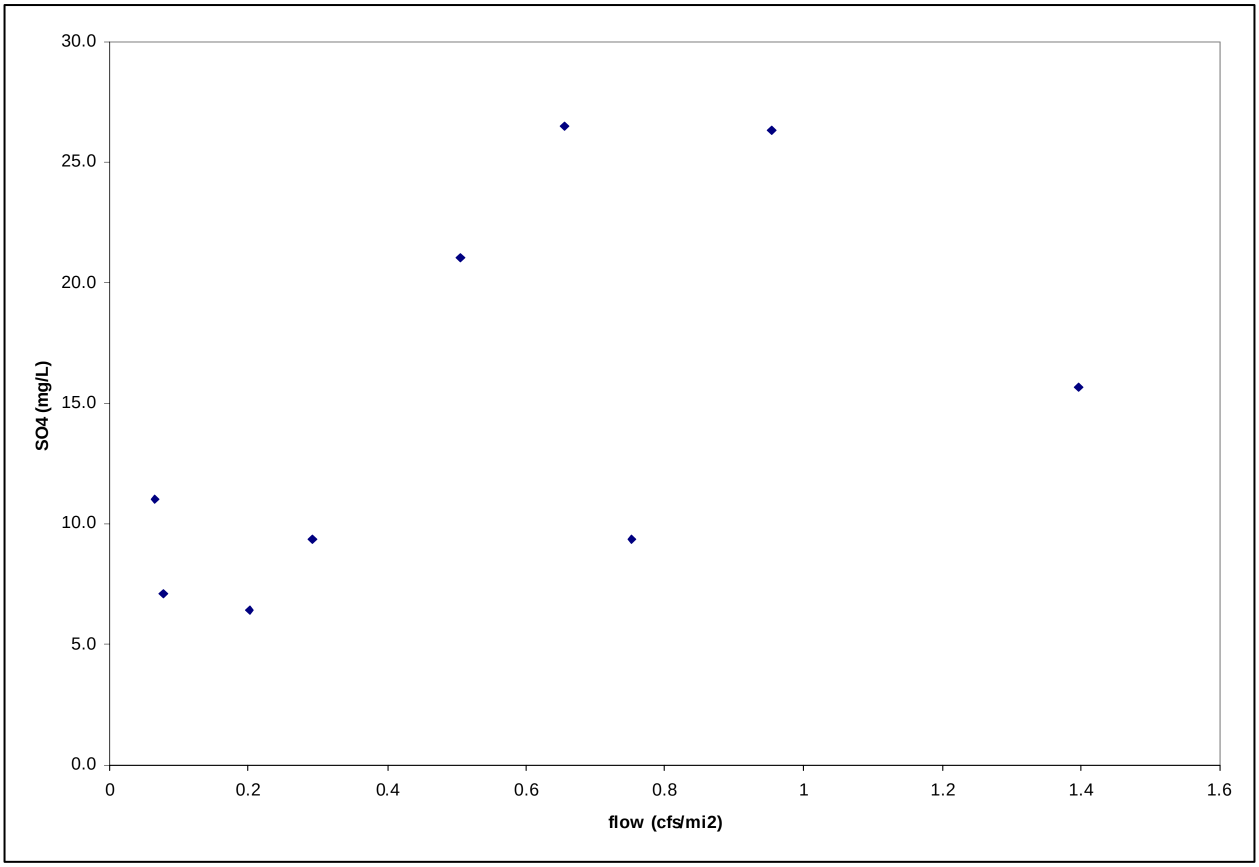

Figure E-4. Sulfate versus flow at unnamed tributary of Grand Bayou (subsegment 100710) near Hall Summit, Louisiana (station 1195).

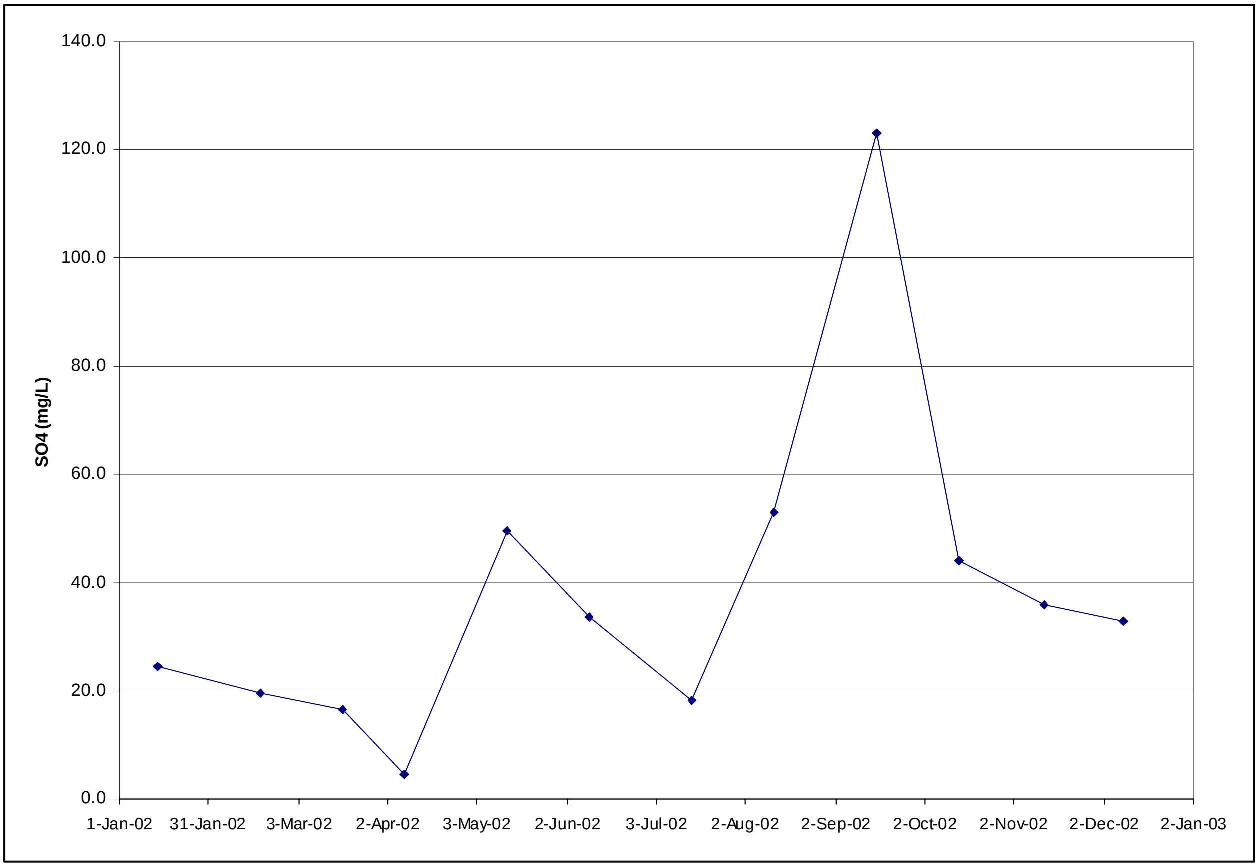

Figure E-5. Sulfate observations at unnamed tributary of Saline Bayou (subsegment 100804) near Arcadia, Louisiana (station 1206).

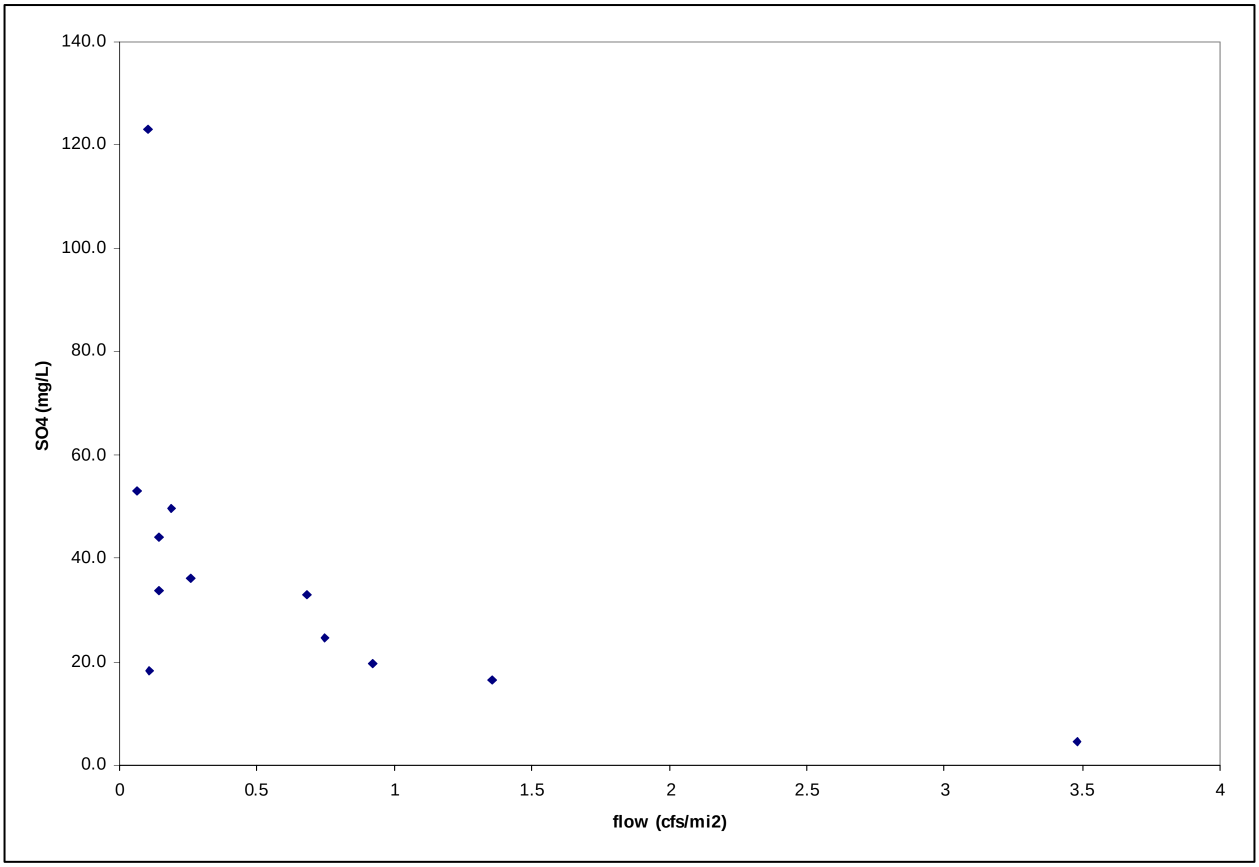

Figure E-6. Sulfate versus flow at unnamed tributary of Saline Bayou (subsegment 100804) near Arcadia, Louisiana (station 1206).

Appendix F
Total Dissolved Solids Figures for the Red River Basin

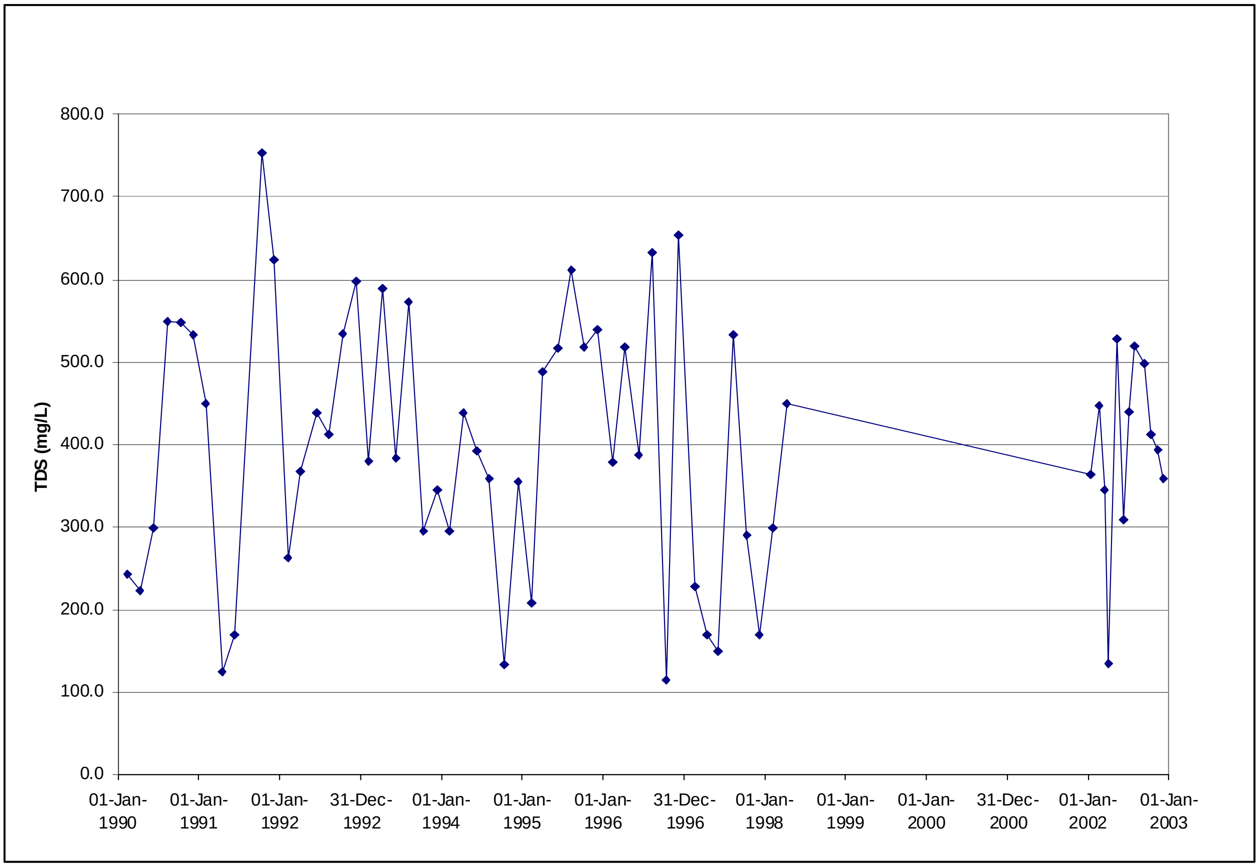

Figure F-1. TDS observations at Flat River (subsegment 100406) east of Taylortown, Louisiana (station 272).

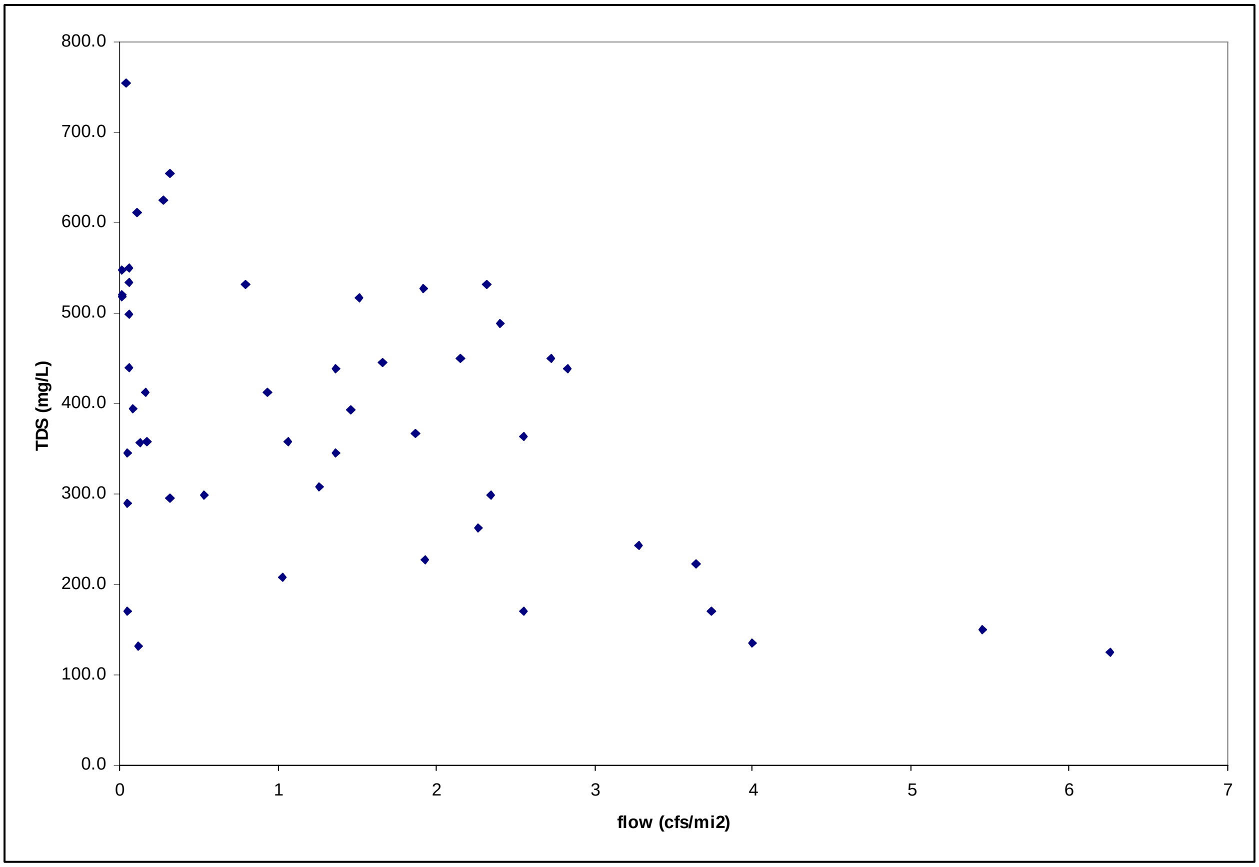

Figure F-2. TDS versus flow at Flat River (subsegment 100406) east of Taylortown, Louisiana (station 272).

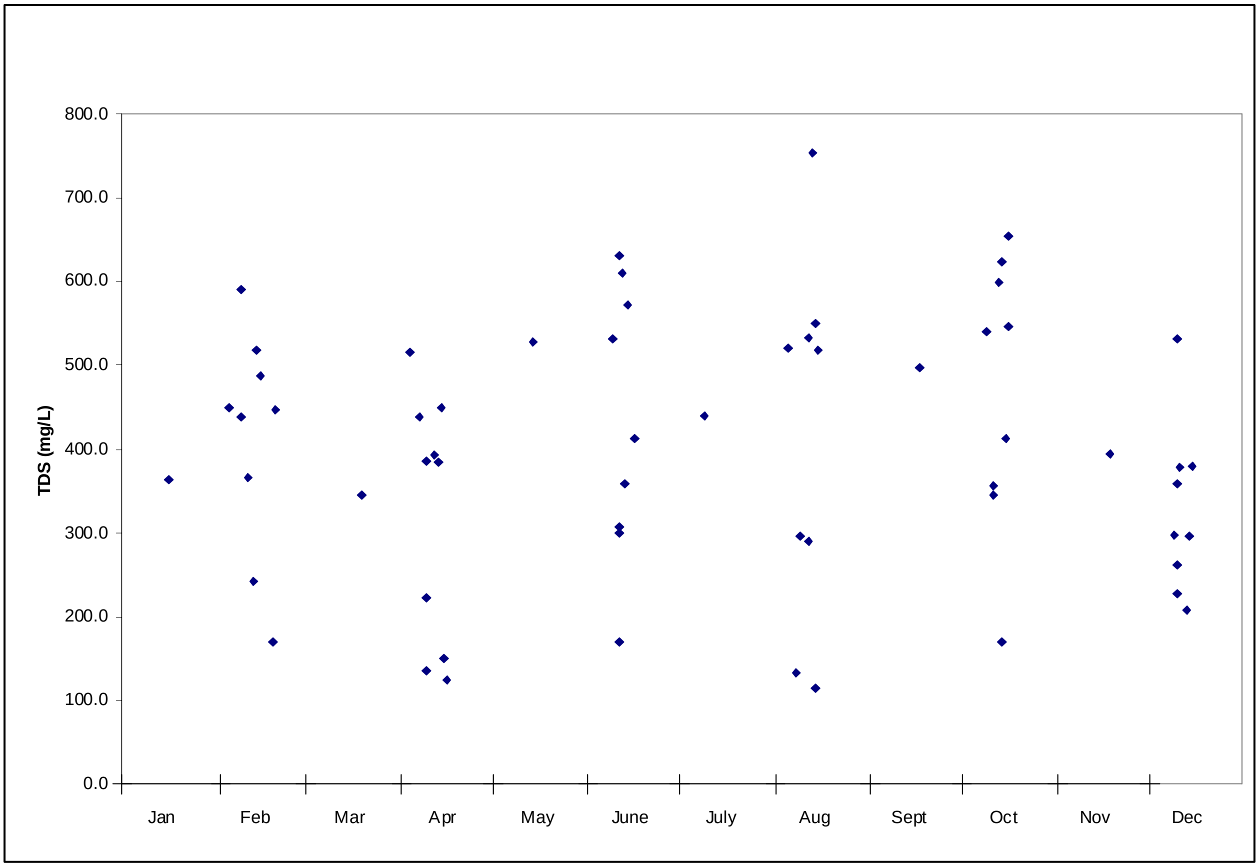

Figure F-3. TDS by season at Flat River (subsegment 100406) east of Taylortown, Louisiana (station 272).

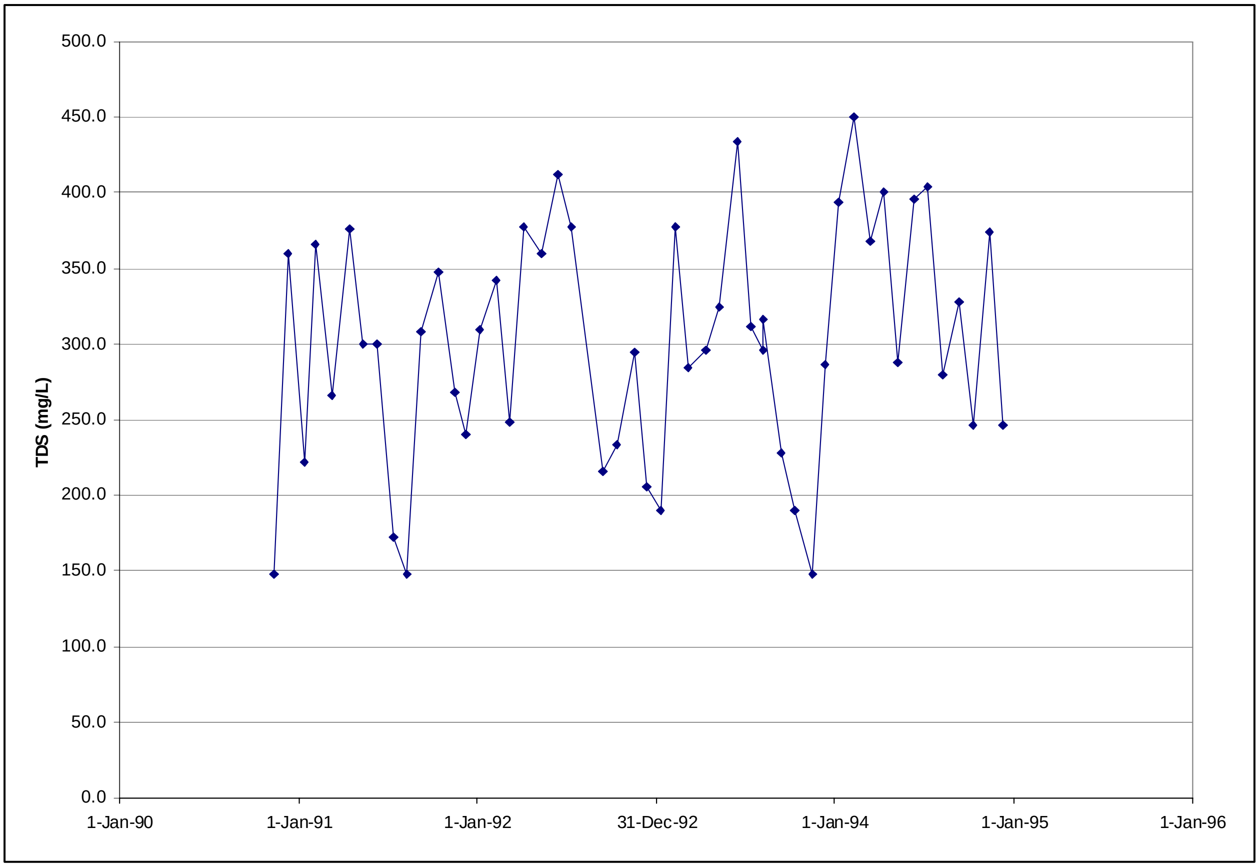

Figure F-4. TDS observations at Flat River Drainage Canal (subsegment 100406) north of Bossier City, Louisiana (station 363).

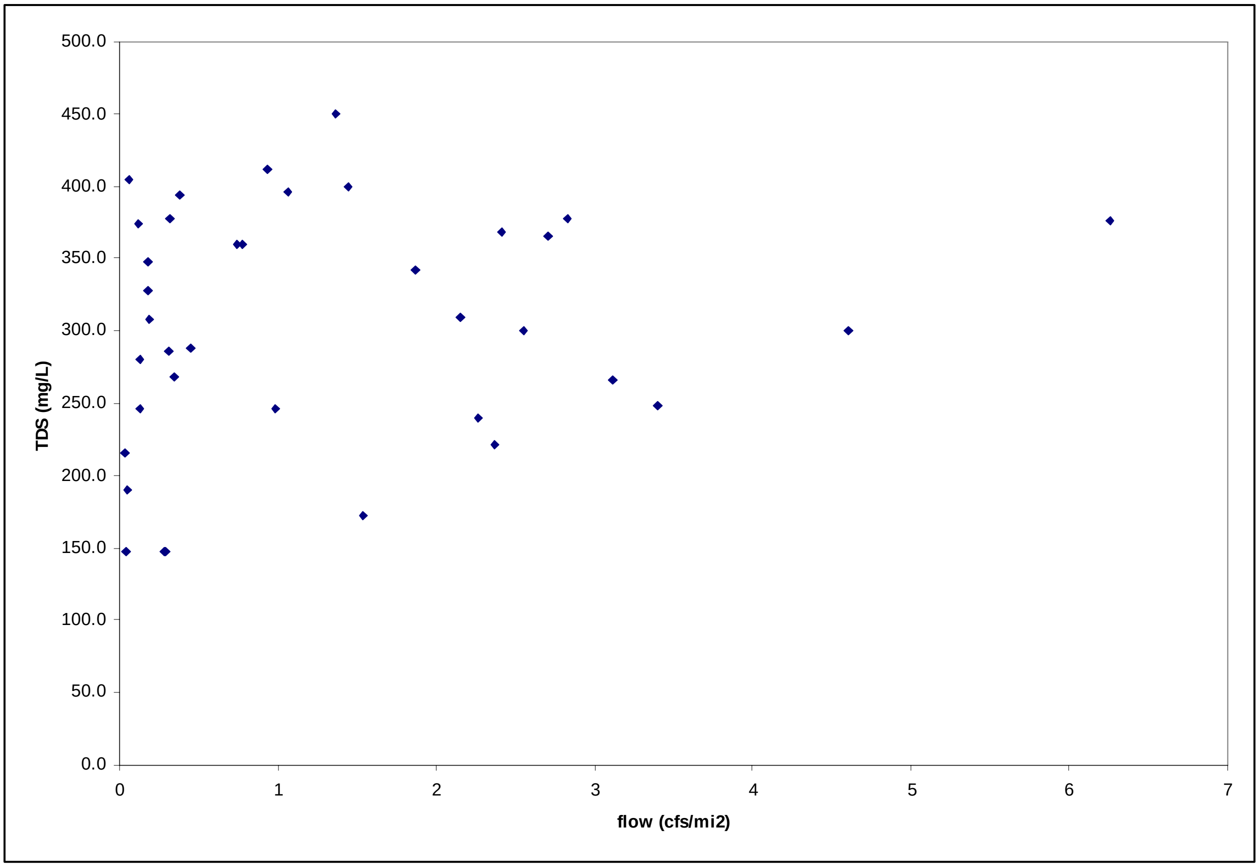

Figure F-5. TDS versus flow at Flat River Drainage Canal (subsegment 100406) north of Bossier City, Louisiana (station 363).

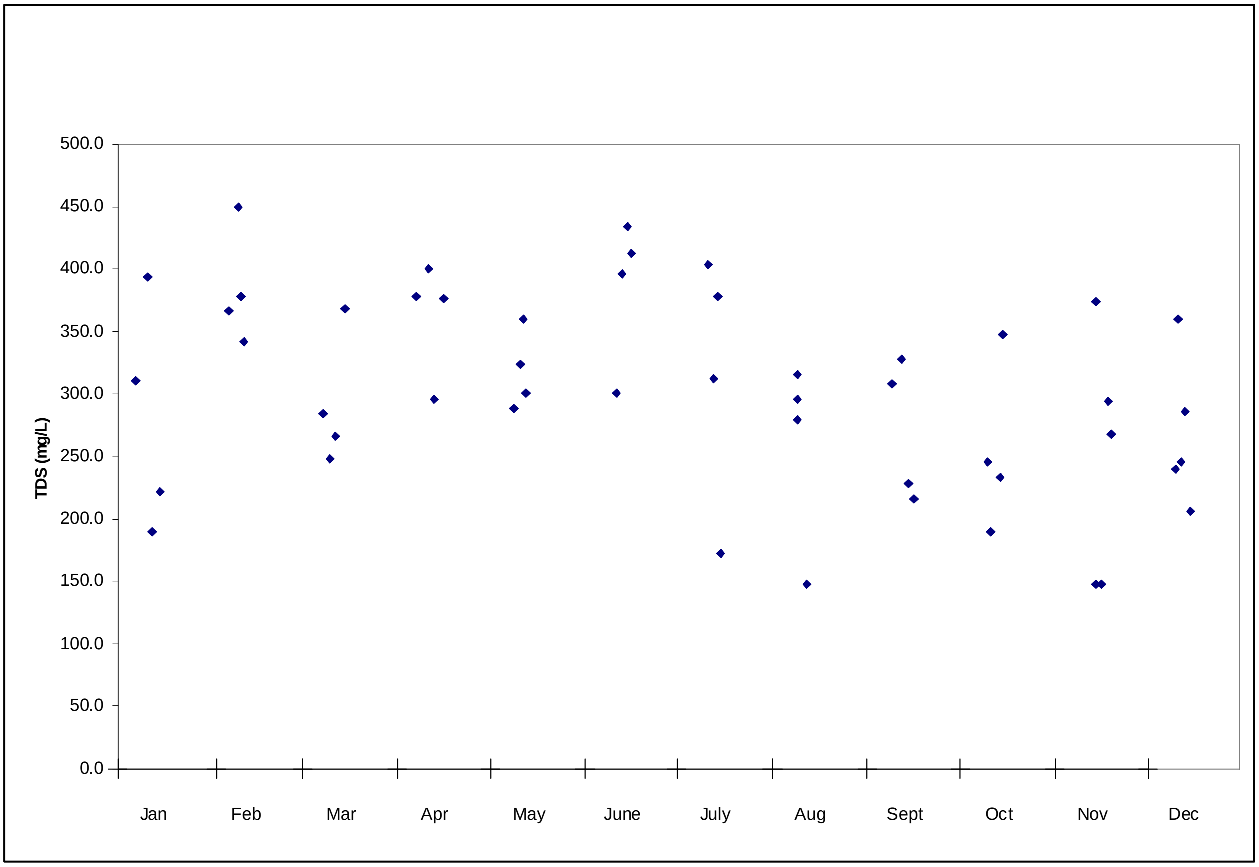

Figure F-6. TDS by season at Flat River Drainage Canal (subsegment 100406) north of Bossier City, Louisiana (station 363).

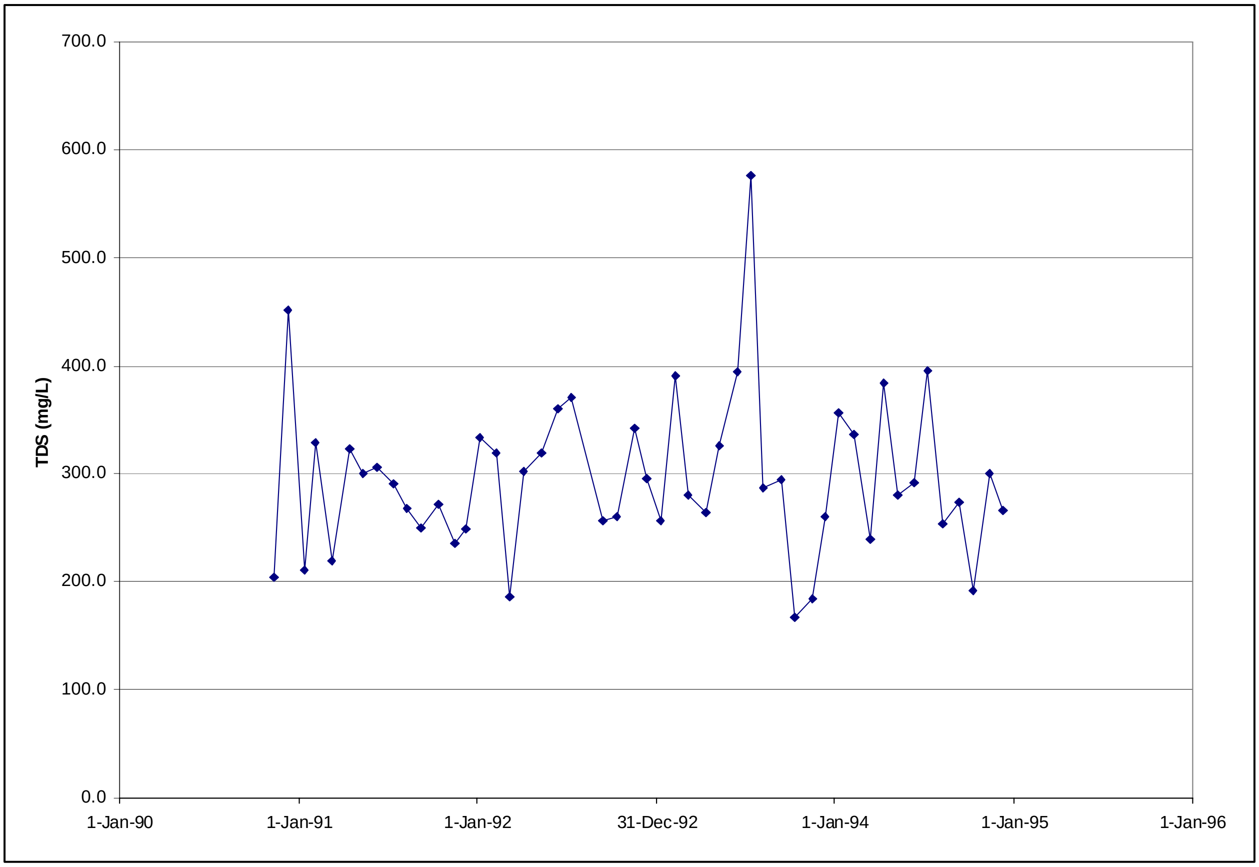

Figure F-7. TDS observations at Flat River Drainage Canal (subsegment 100406) northeast of Bossier City, Louisiana (station 389).

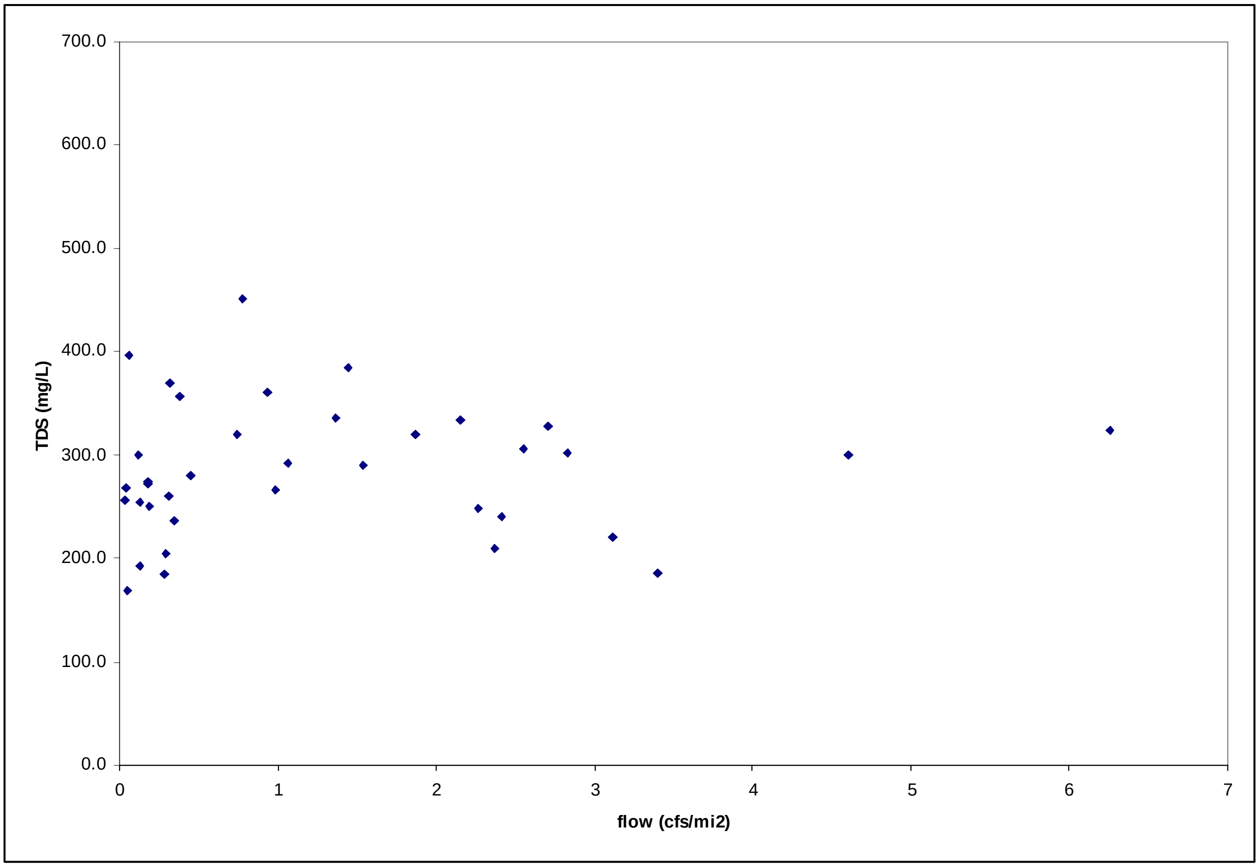

Figure F-8. TDS versus flow at Flat River Drainage Canal (subsegment 100406) northeast of Bossier City, Louisiana (station 389).

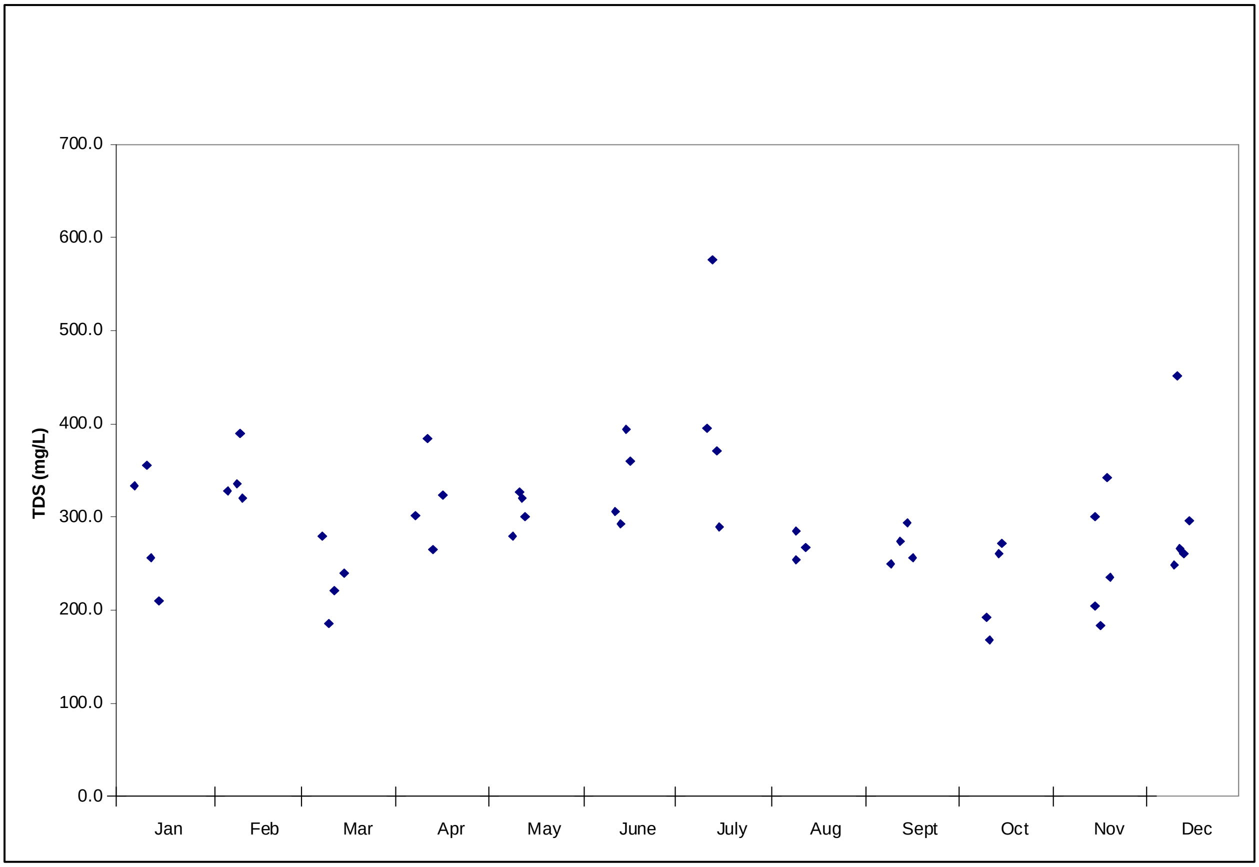

Figure F-9. TDS by season at Flat River Drainage Canal (subsegment 100406) northeast of Bossier City, Louisiana (station 389).

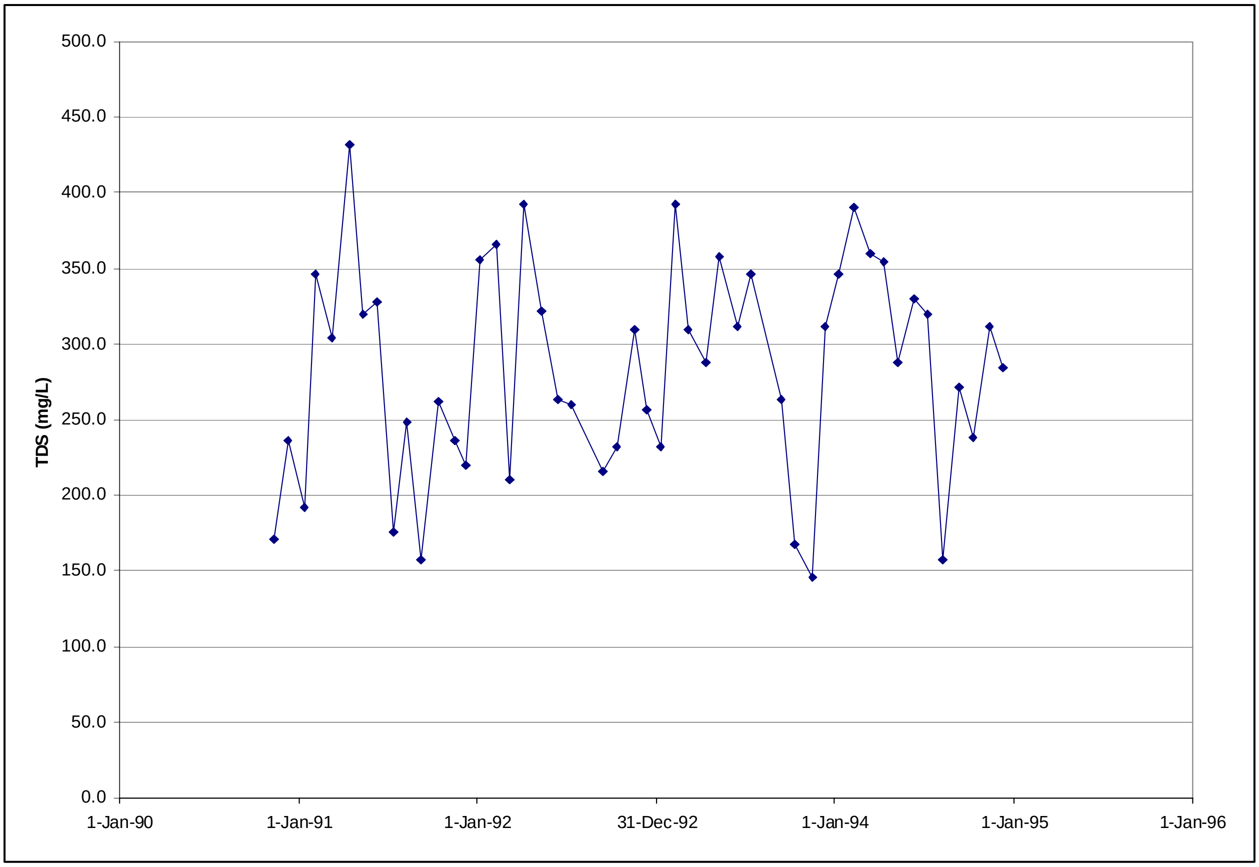

Figure F-10. TDS observations at Flat River Drainage Canal (subsegment 100406) northeast of Shreveport, Louisiana (station 390).

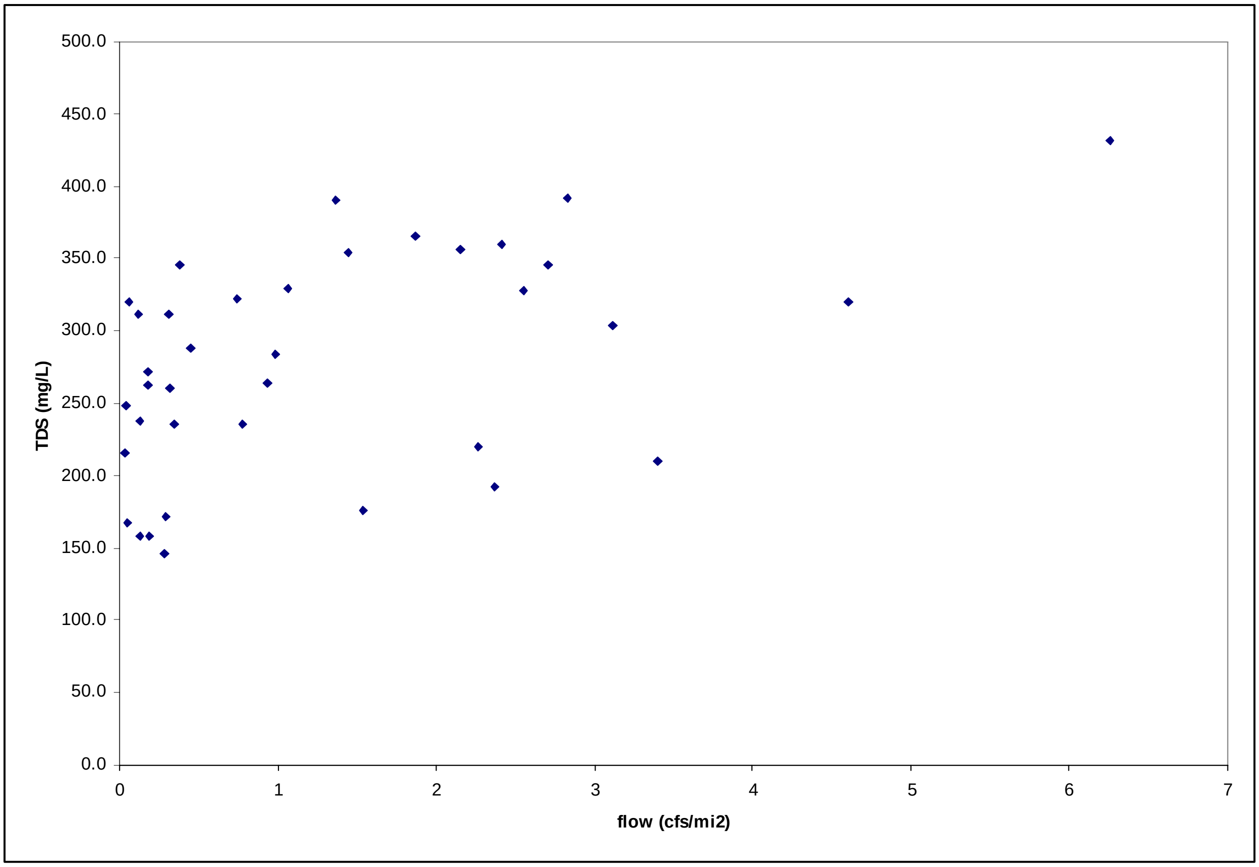

Figure F-11. TDS versus flow at Flat River Drainage Canal (subsegment 100406) northeast of Shreveport, Louisiana (station 390).

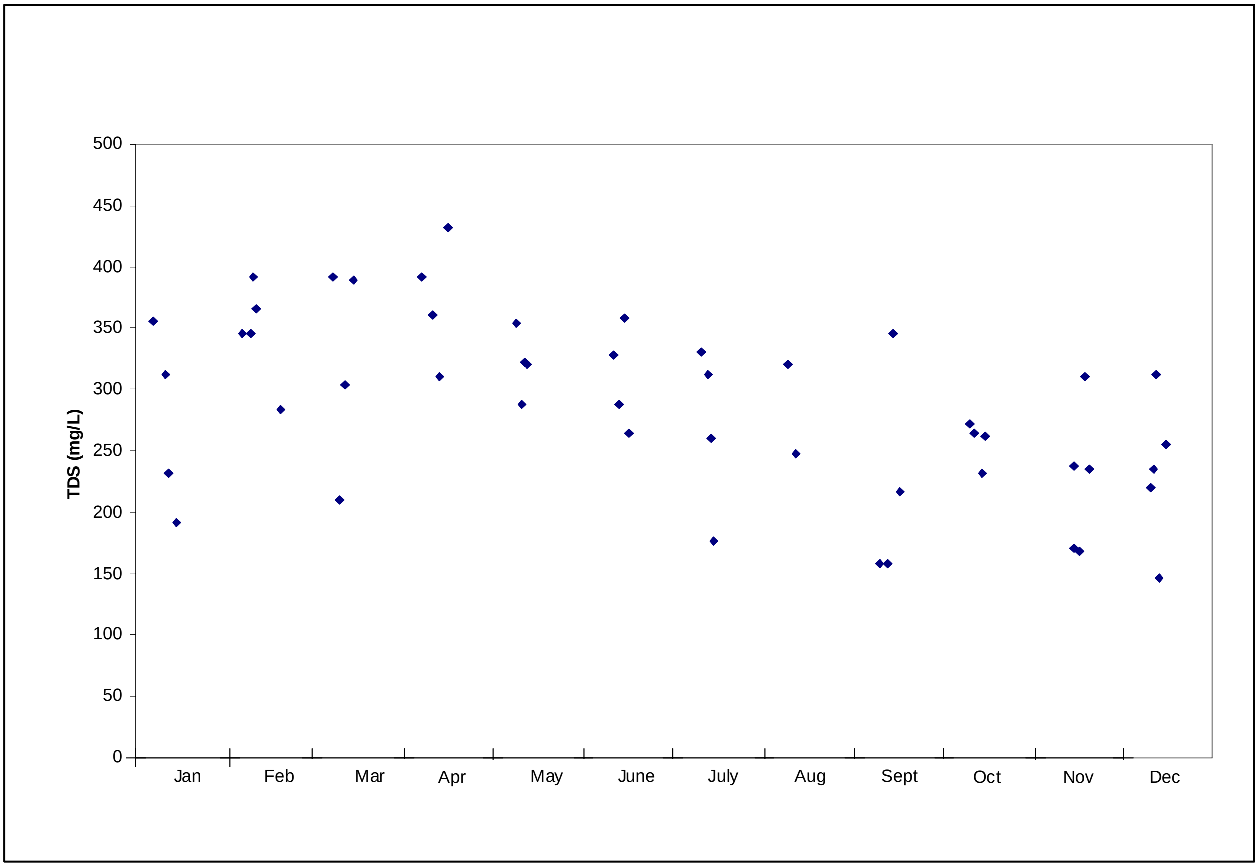

Figure F-12. TDS by season at Flat River Drainage Canal (subsegment 100406) northeast of Shreveport, Louisiana (station 390).

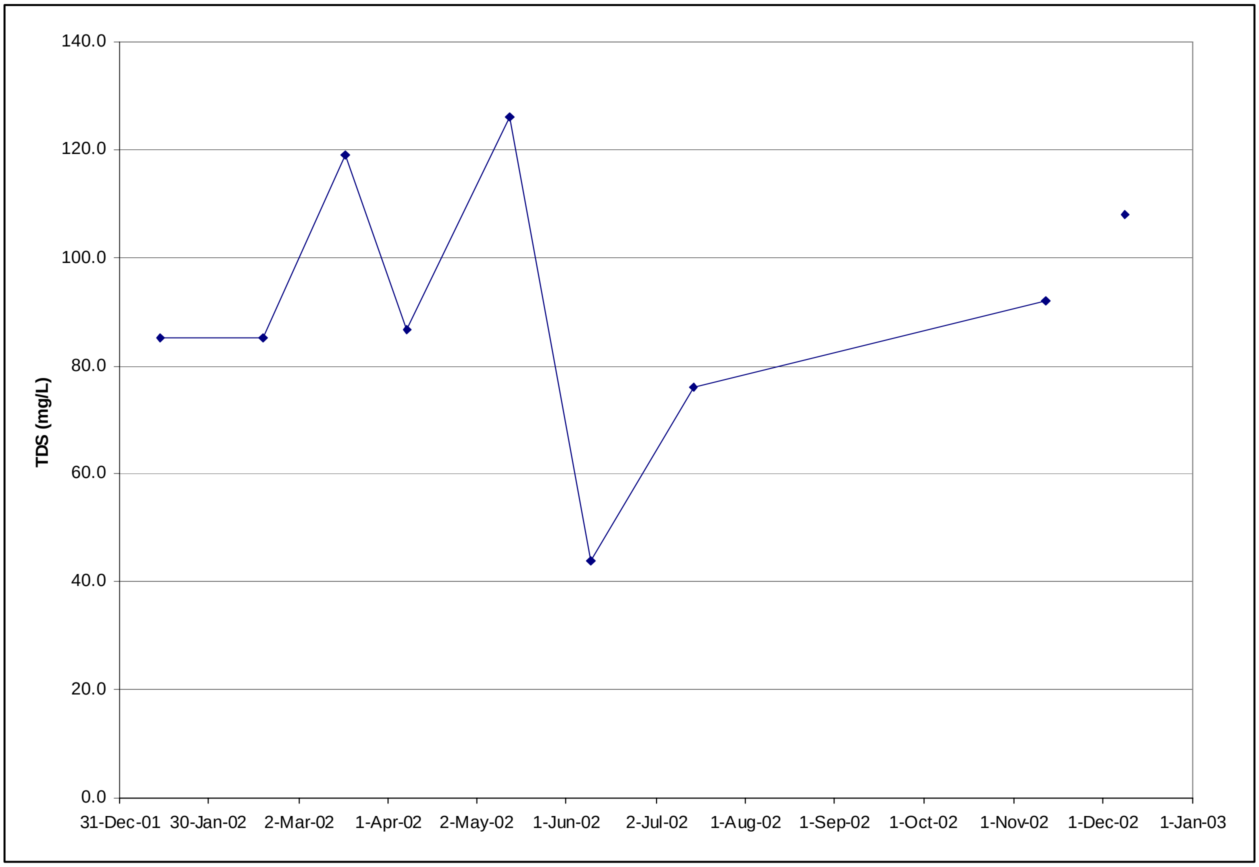

Figure F-13. TDS observations at unnamed tributary of Castor Creek (subsegment 100708) near Castor, Louisiana (station 1194).

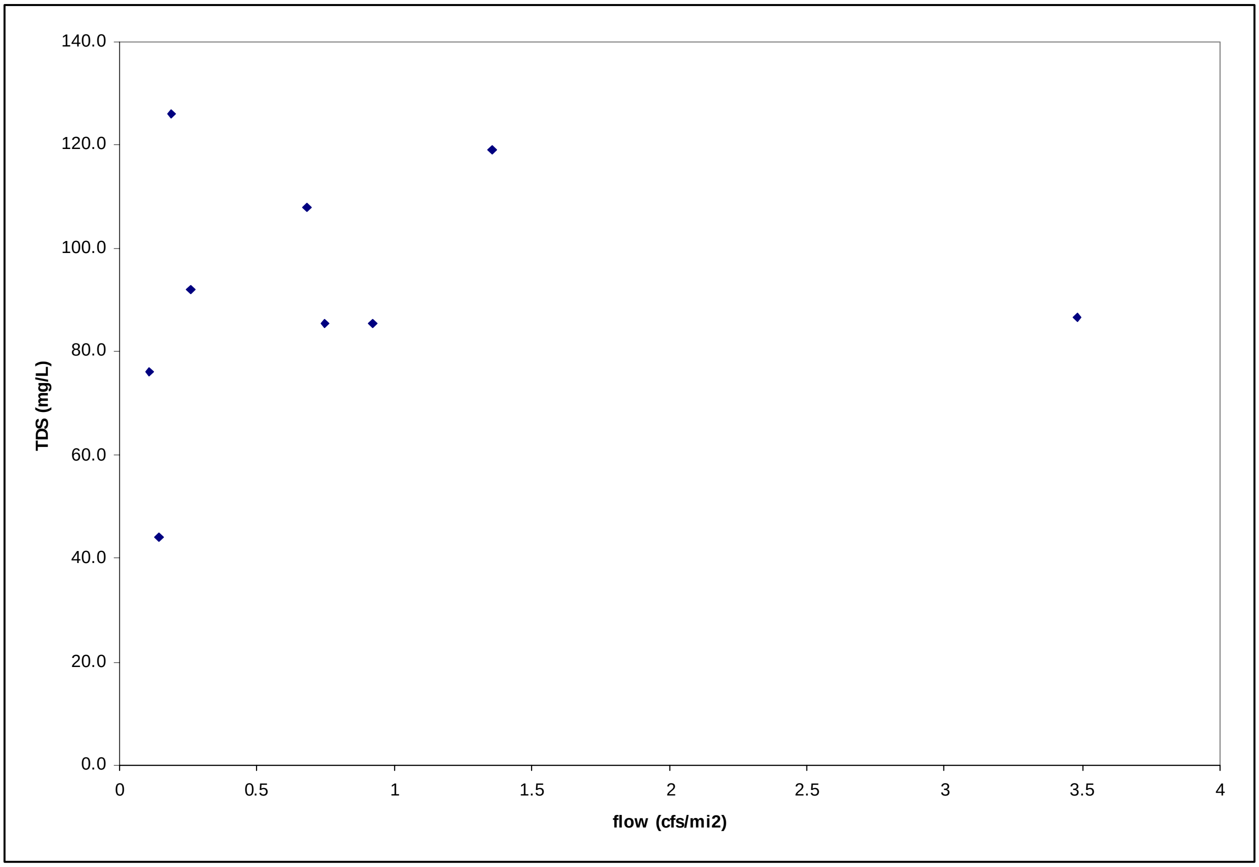

Figure F-14. TDS versus flow at unnamed tributary of Castor Creek (subsegment 100708) near Castor, Louisiana (station 1194).

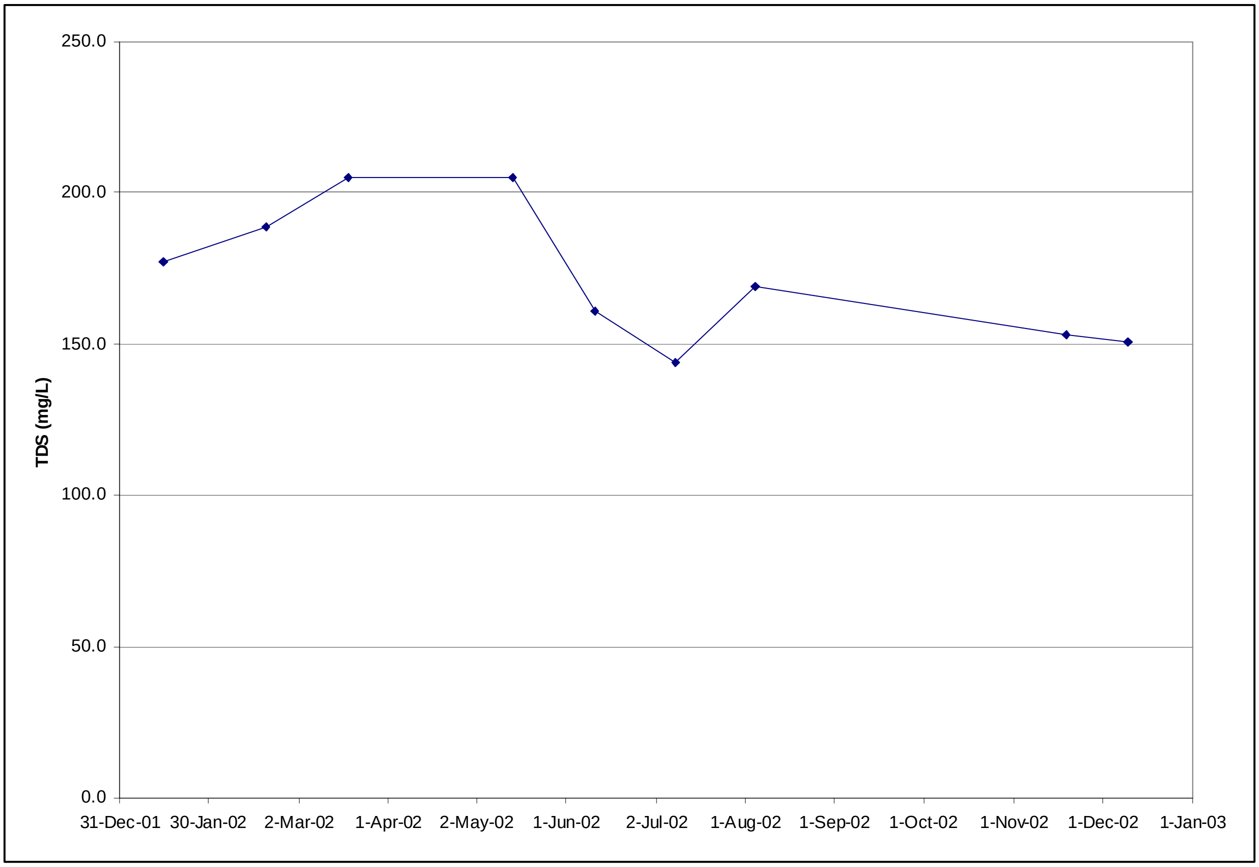

Figure F-15. TDS observations at unnamed tributary of Grand Bayou (subsegment 100710) near Hall Summit, Louisiana (station 1195).

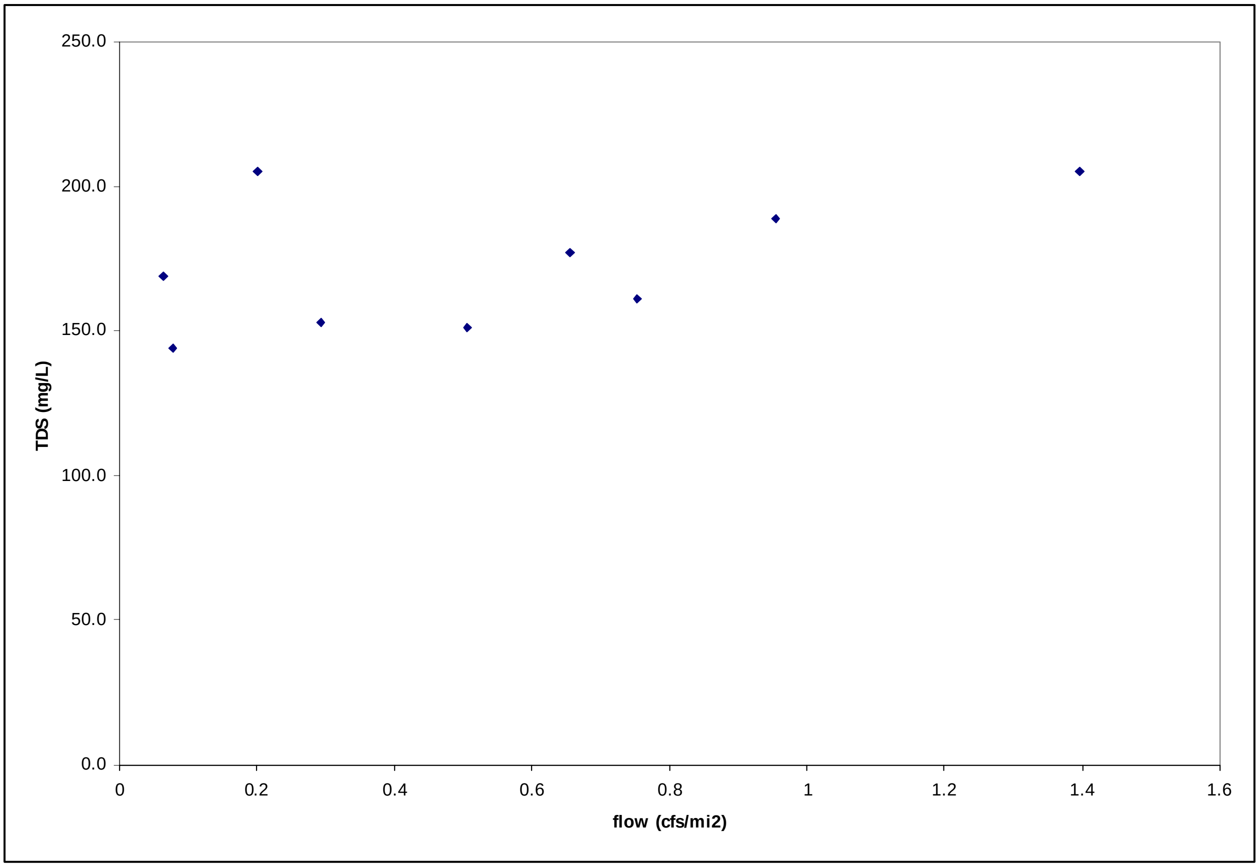

Figure F-16. TDS versus flow at unnamed tributary of Grand Bayou (subsegment 100710) near Hall Summit, Louisiana (station 1195).

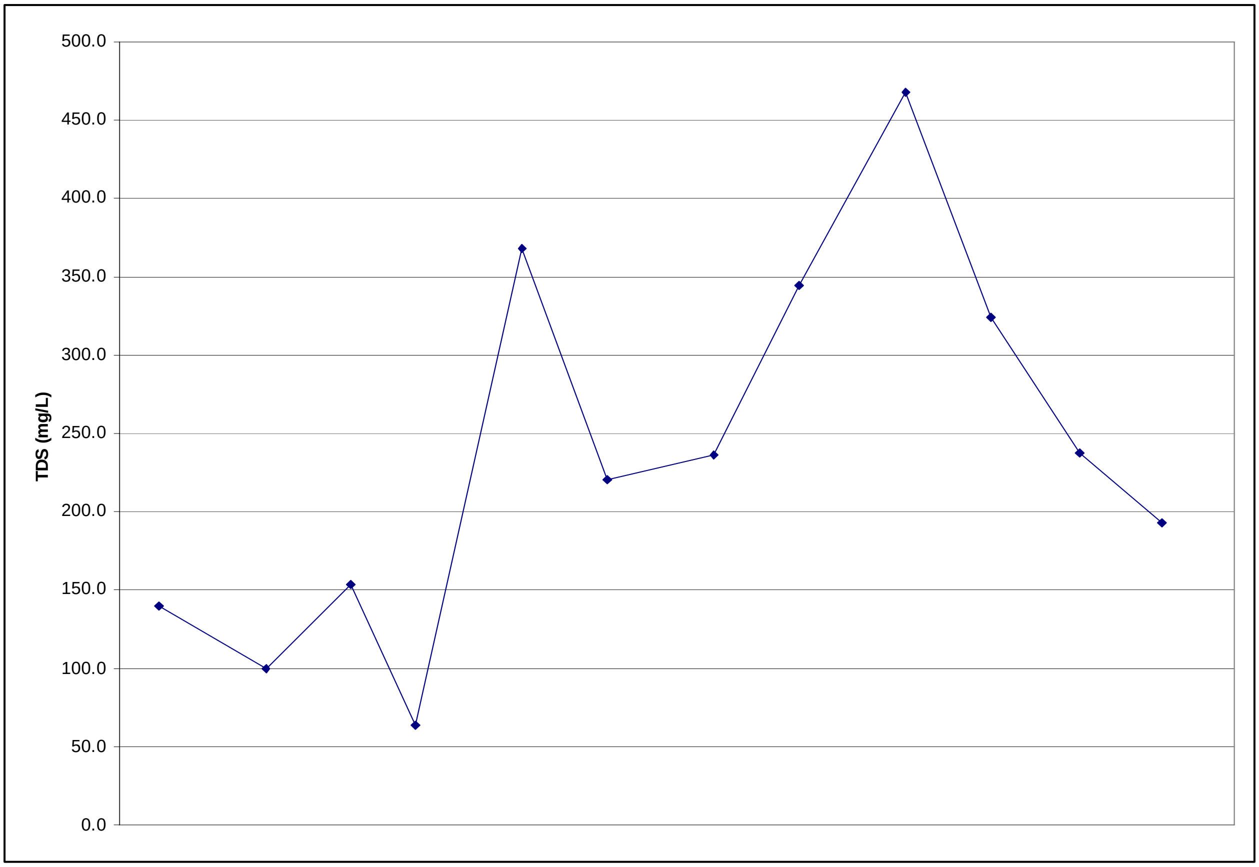

Figure F-17. TDS observations at unnamed tributary of Saline Bayou (subsegment 100804) near Arcadia, Louisiana (station 1206).

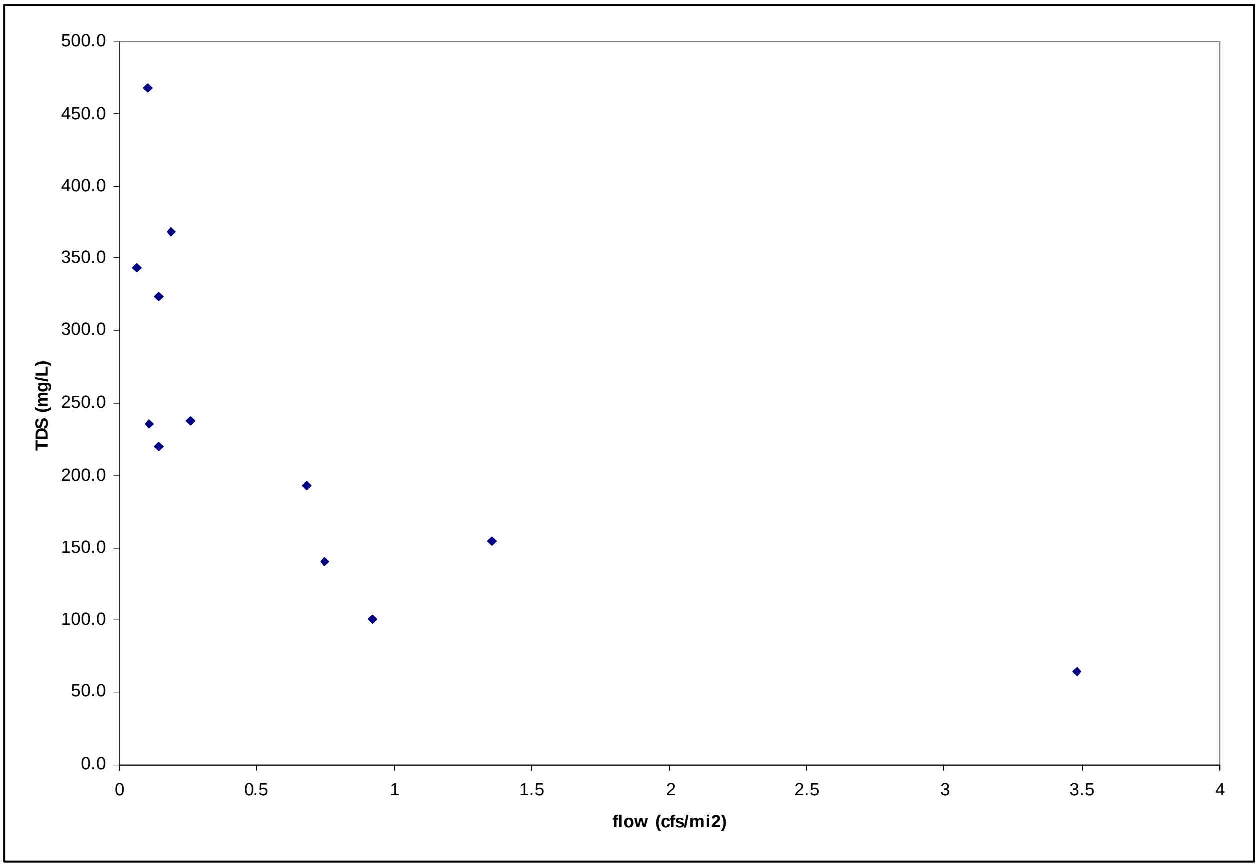

Figure F-18. TDS versus flow at unnamed tributary of Saline Bayou (subsegment 100804) near Arcadia, Louisiana (station 1206).

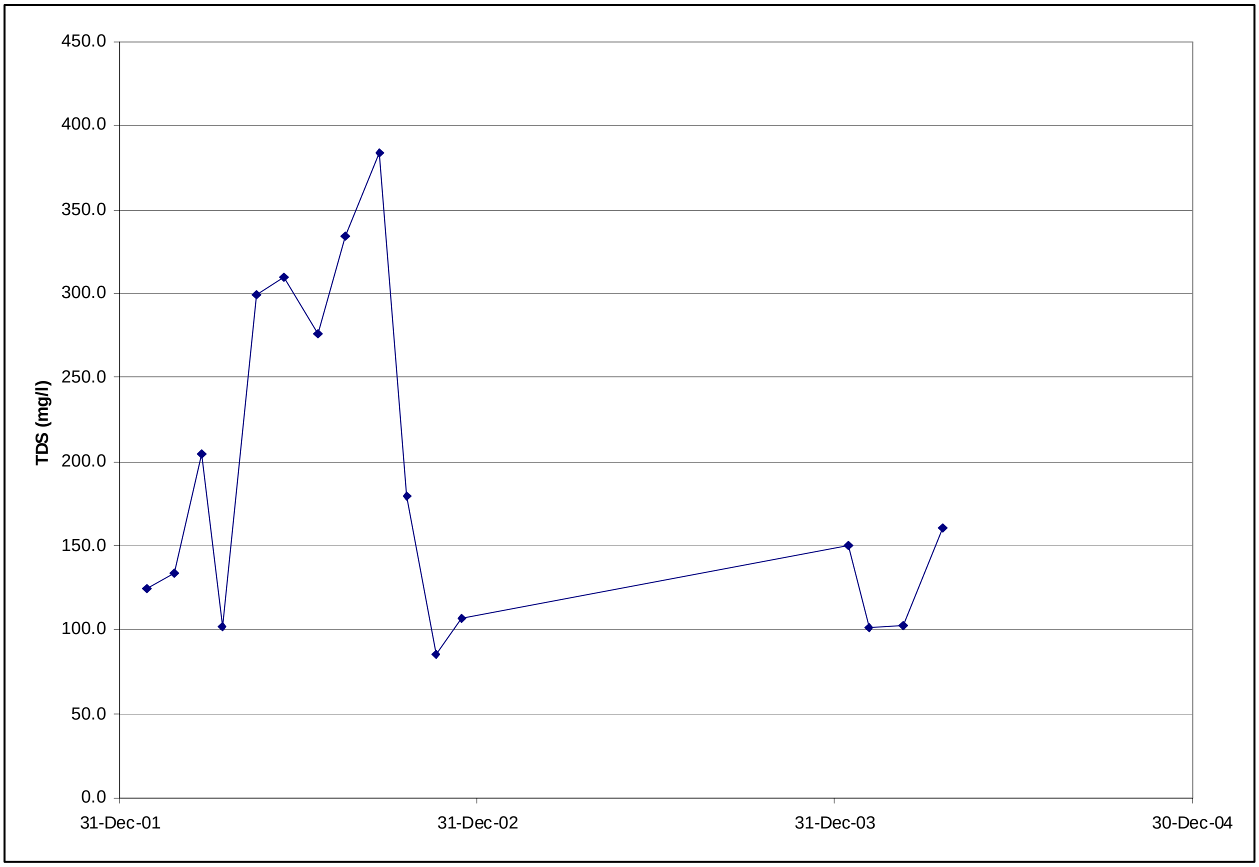

Figure F-19. TDS observations at Cane River (subsegment 101101) west of Colfax, Louisiana (station 1217).

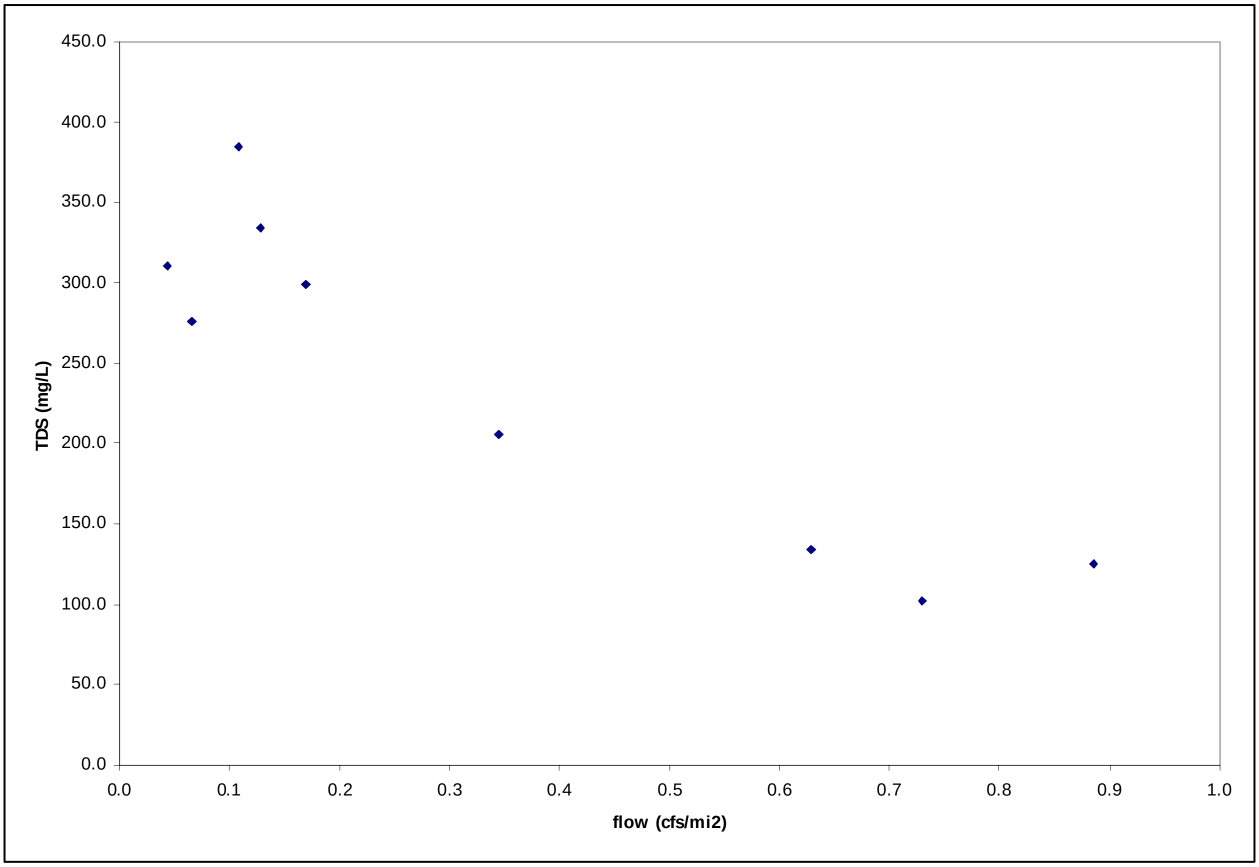

Figure F-20. TDS versus flow at Cane River (subsegment 101101) west of Colfax, Louisiana (station 1217).

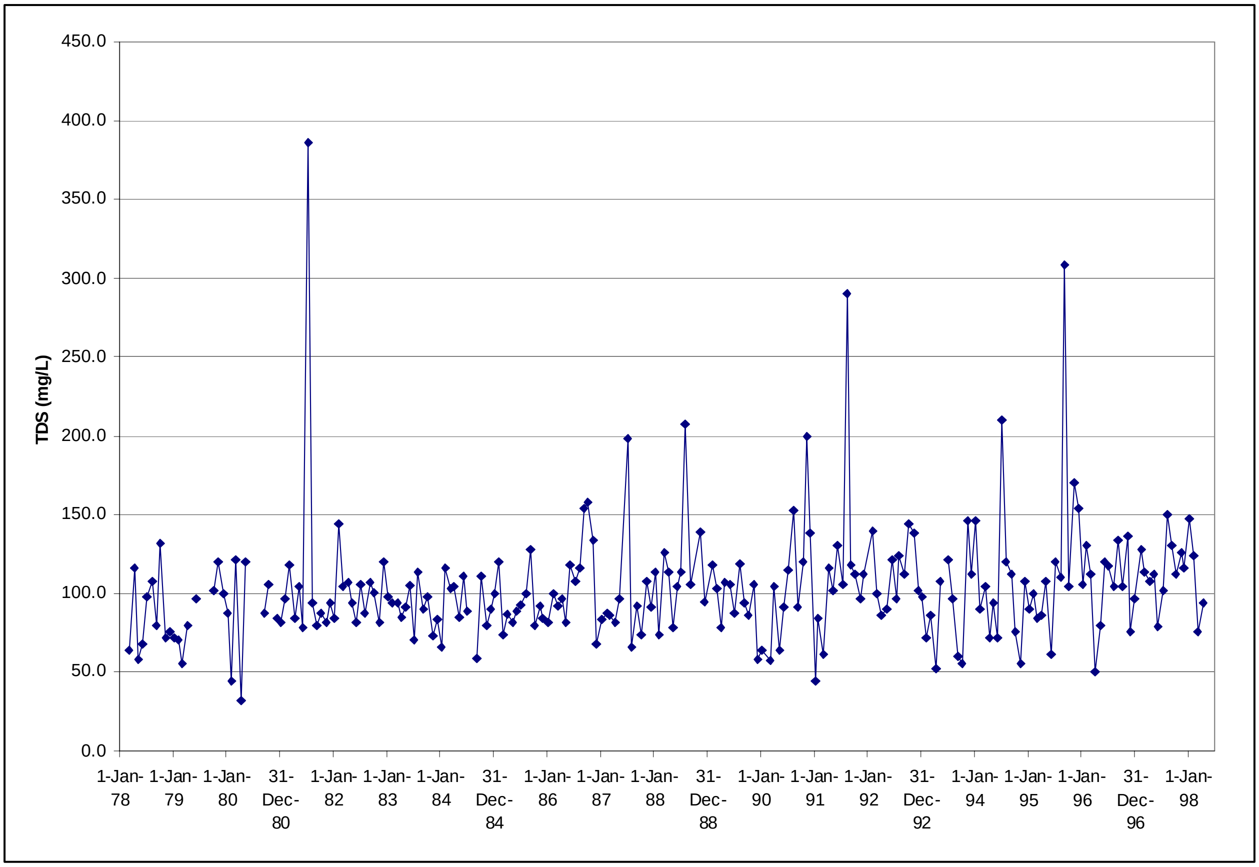

Figure F-21. TDS observations at Kisatchie Bayou (subsegment 101103) near Lotus, Louisiana (station 42).

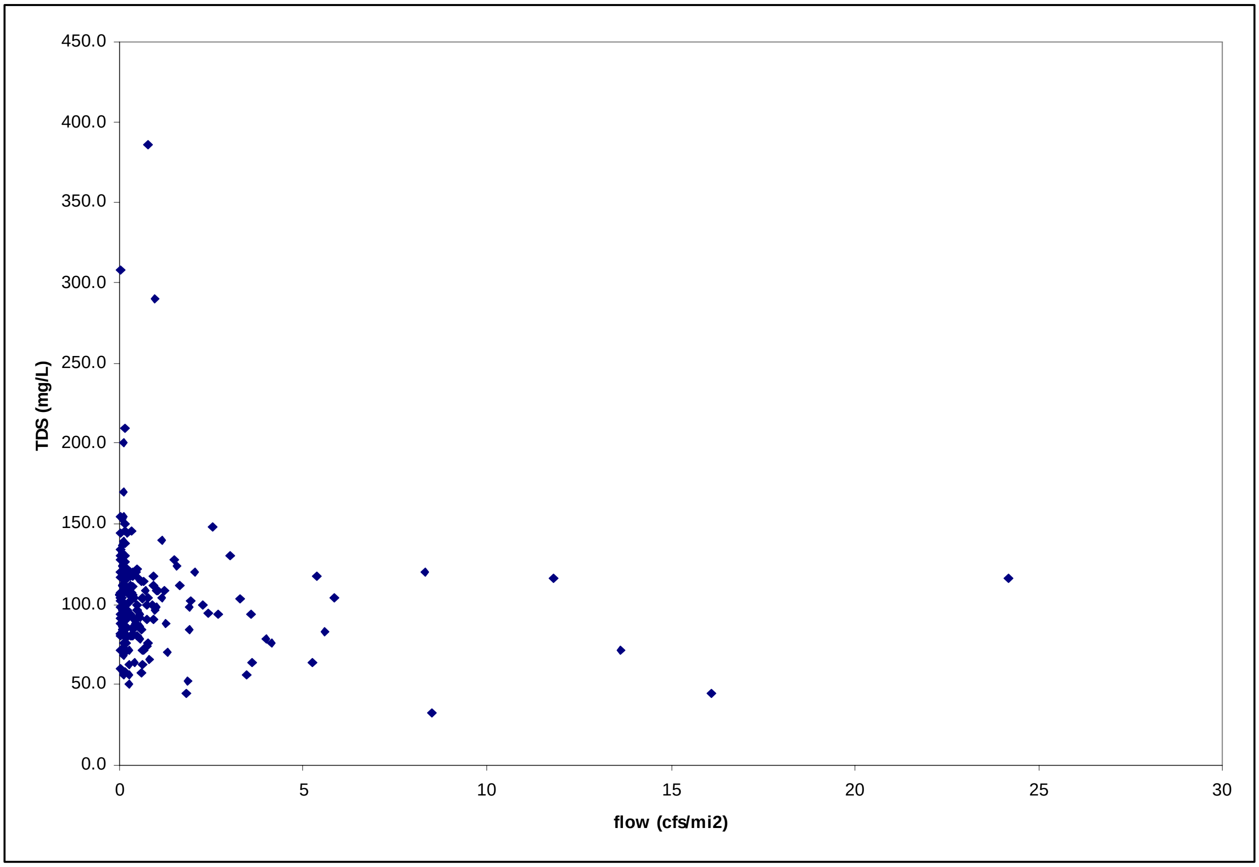

Figure F-22. TDS versus flow at Kisatchie Bayou (subsegment 101103) near Lotus, Louisiana (station 42).

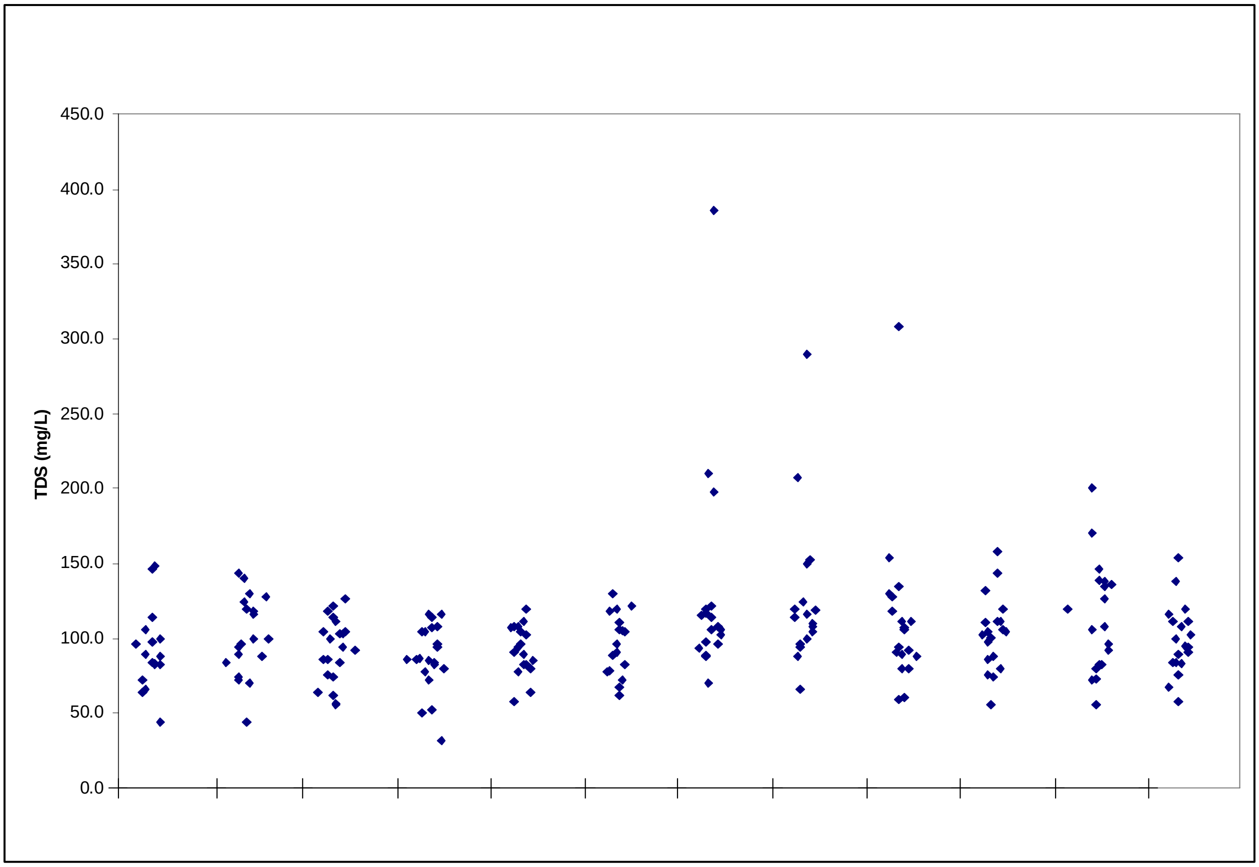

Figure F-23. TDS by season at Kisatchie Bayou (subsegment 101103) near Lotus, Louisiana (station 42).

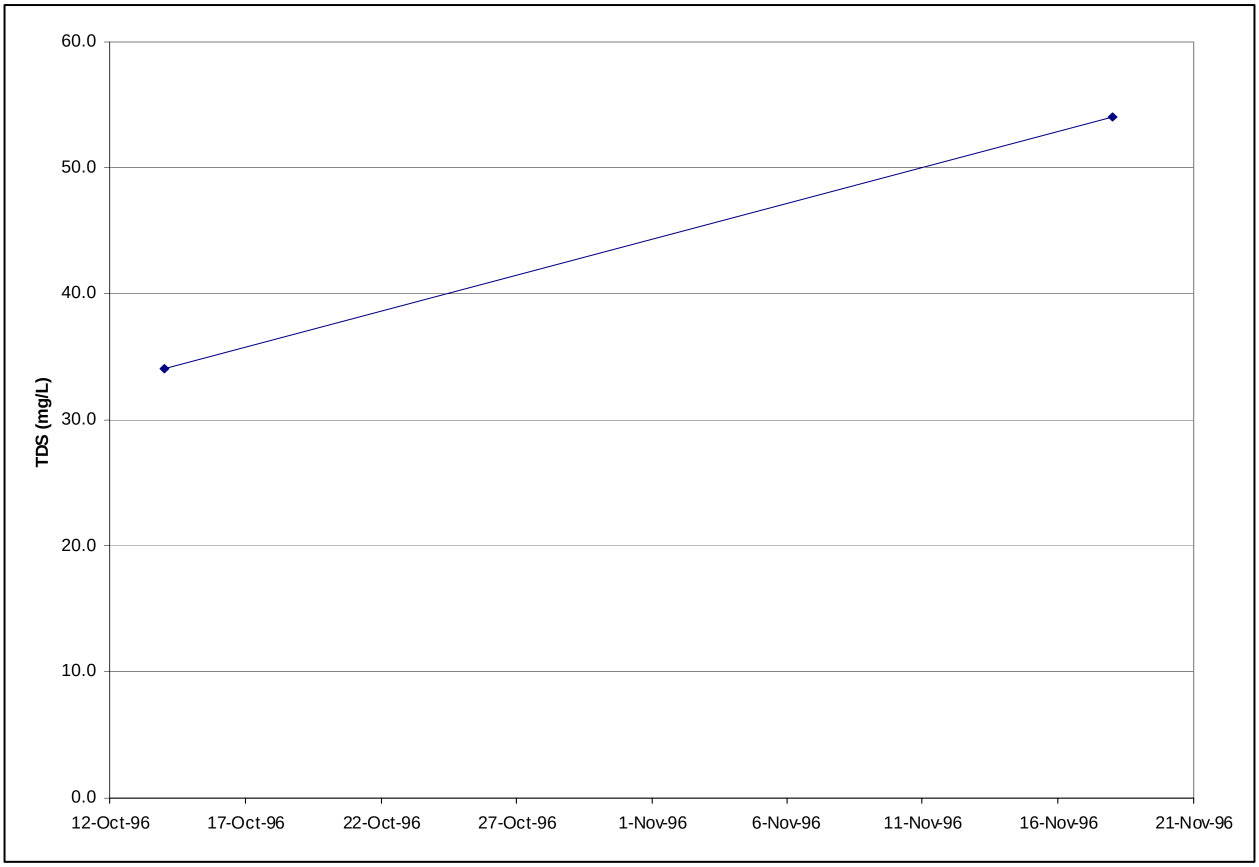

Figure F-24. TDS observations at Kisatchie Bayou (subsegment 101103) at Kisatchie, Louisiana (station 549).

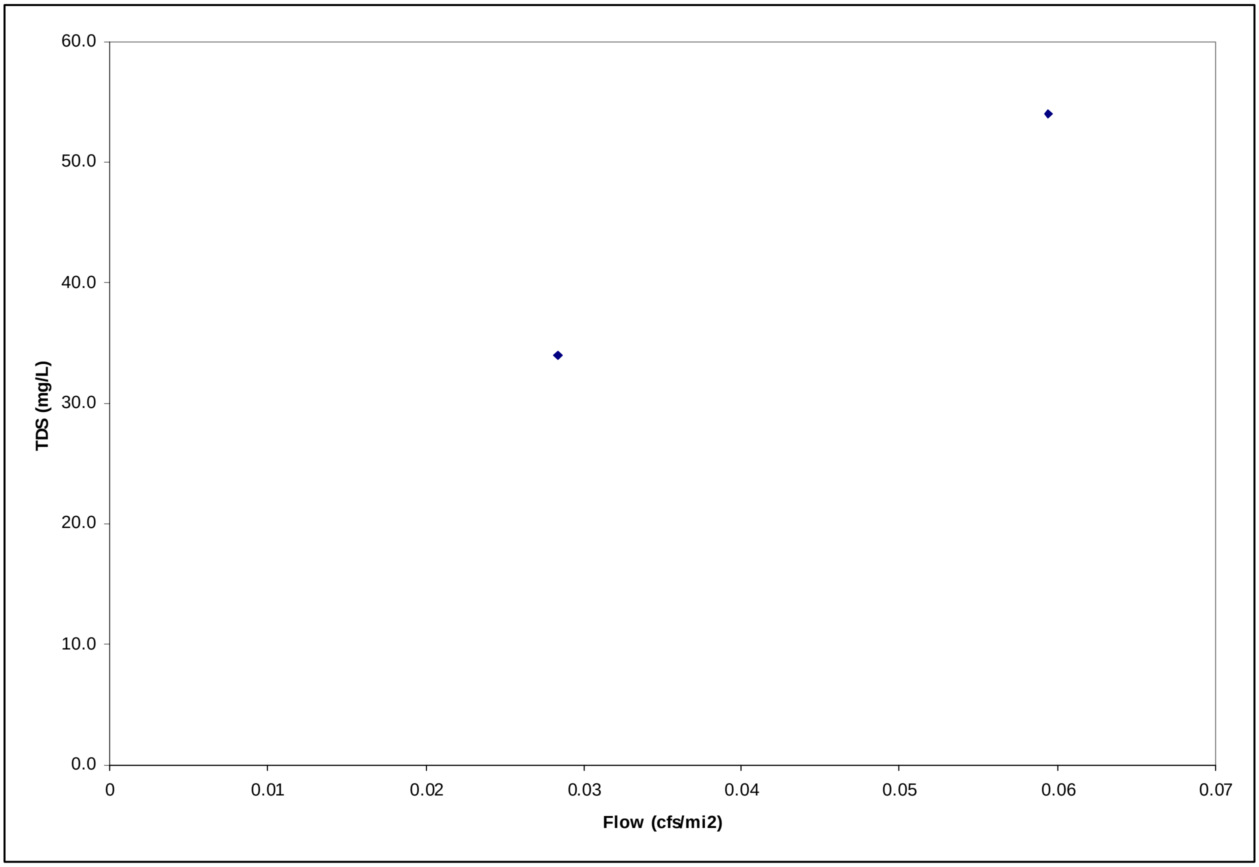

Figure F-25. TDS versus flow at Kisatchie Bayou (subsegment 101103) at Kisatchie, Louisiana (station 549).

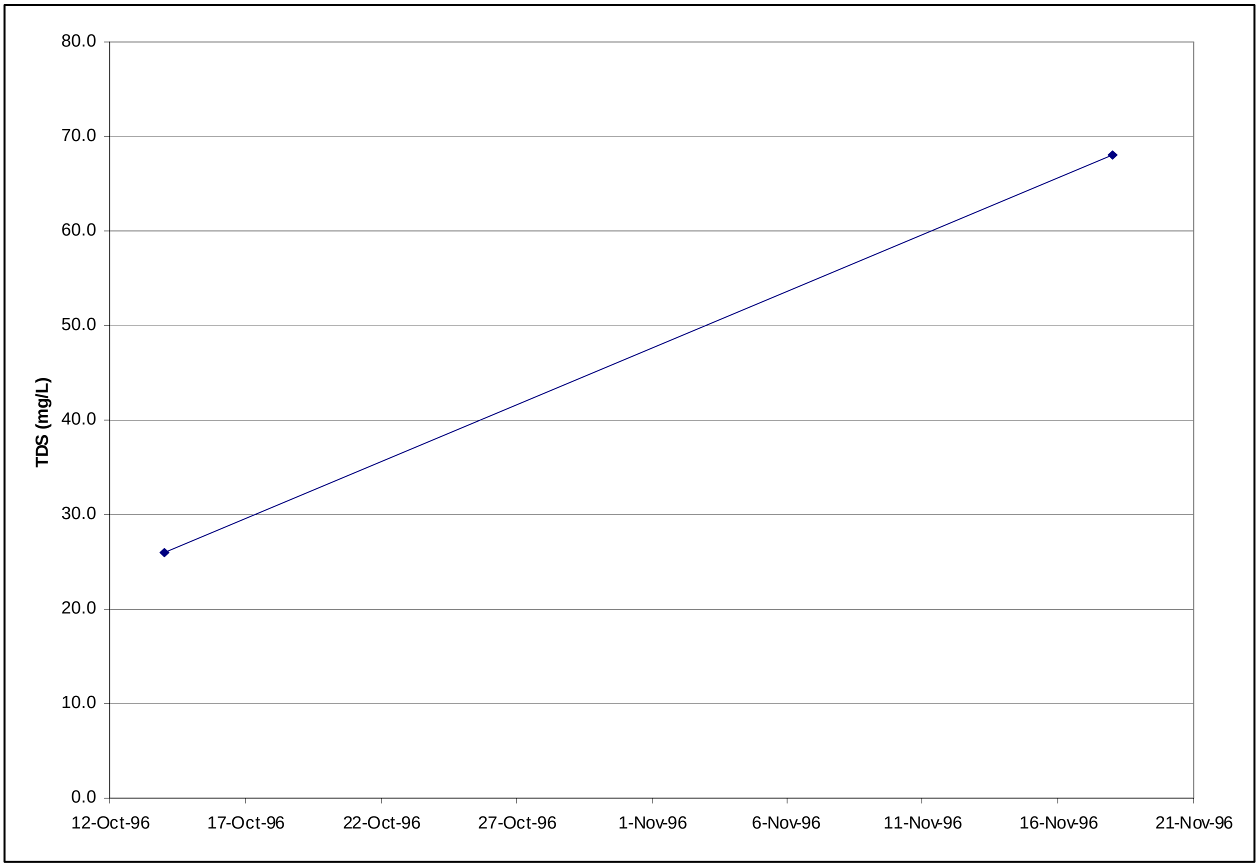

Figure F-26. TDS observations at Little Sandy Creek (subsegment 101103) at Kisatchie, Louisiana (station 550).

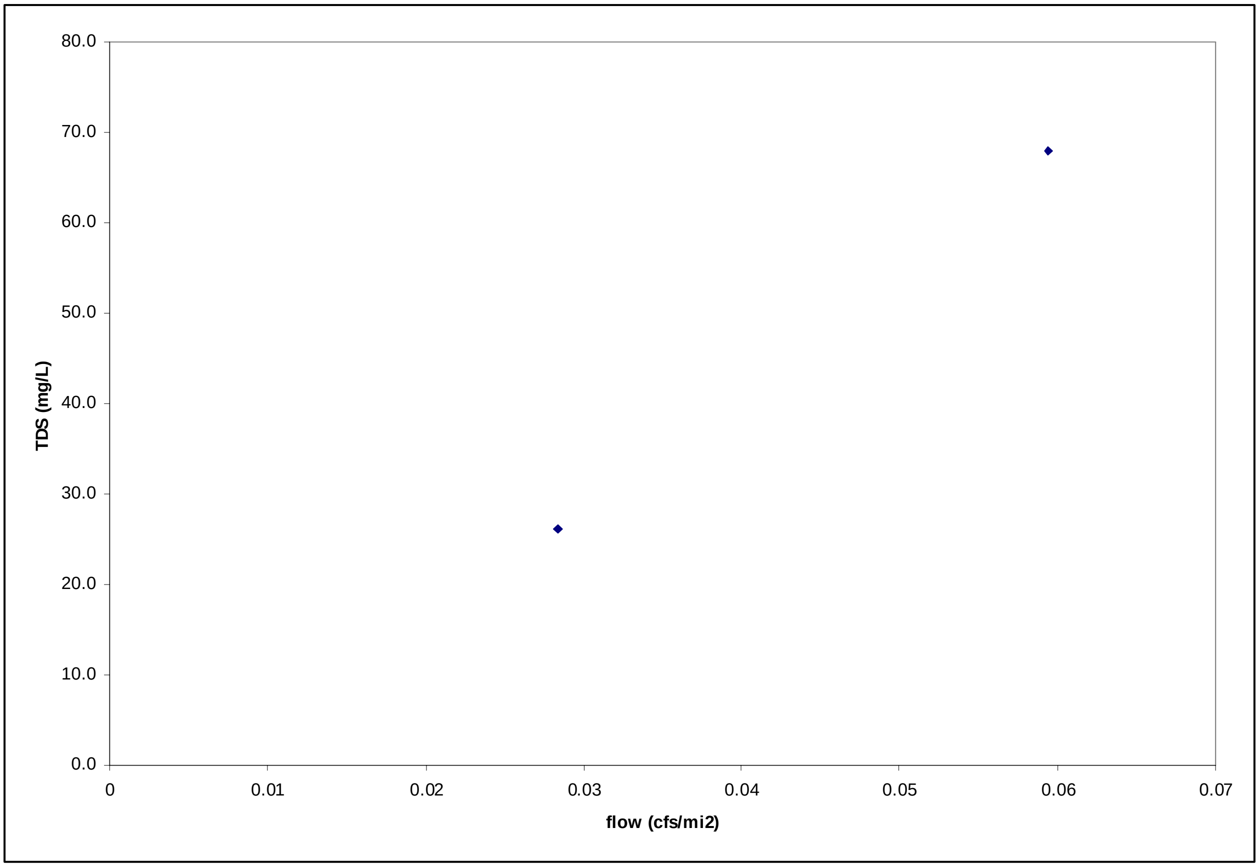

Figure F-27. TDS versus flow at Little Sandy Creek (subsegment 101103) at Kisatchie, Louisiana (station 550).

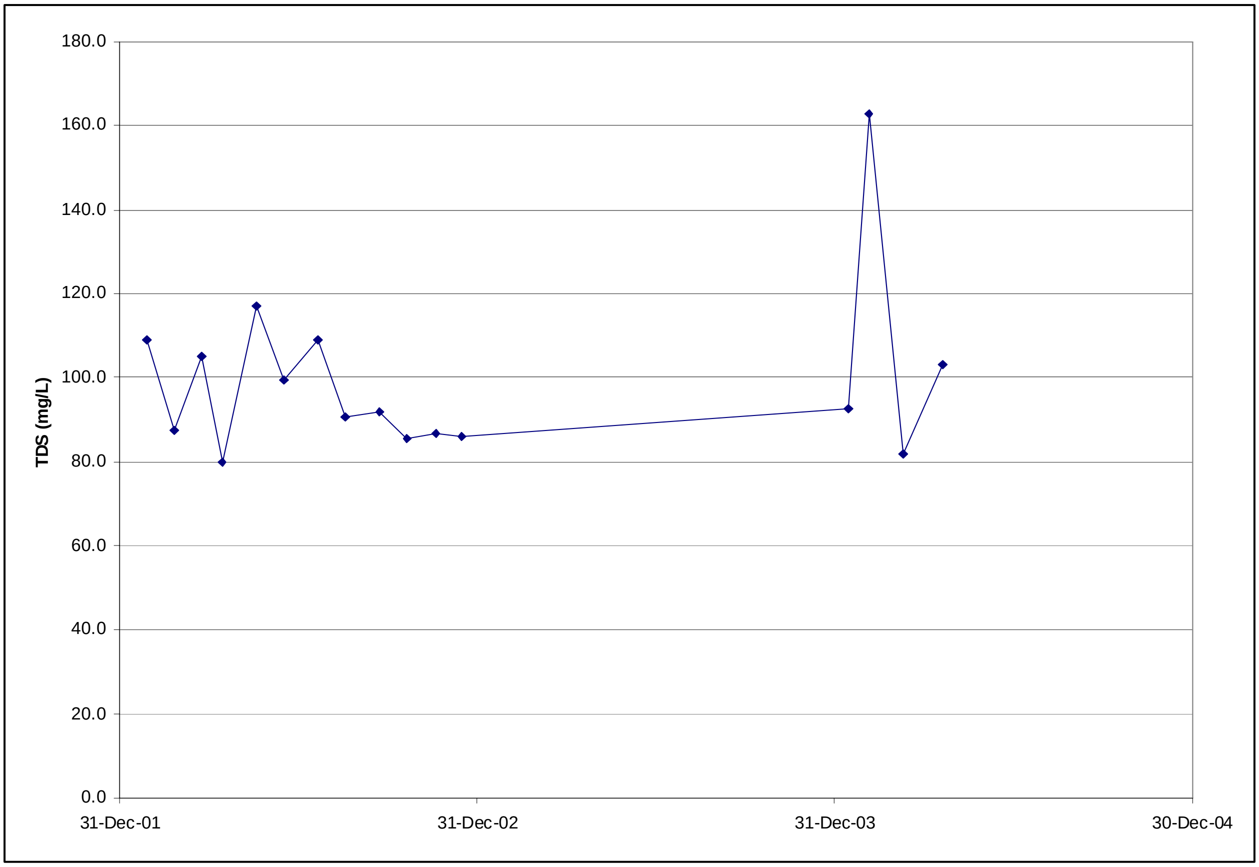

Figure F-28. TDS observations at Kisatchie Bayou (subsegment 101103) south of Cypress, Louisiana (station 1218).

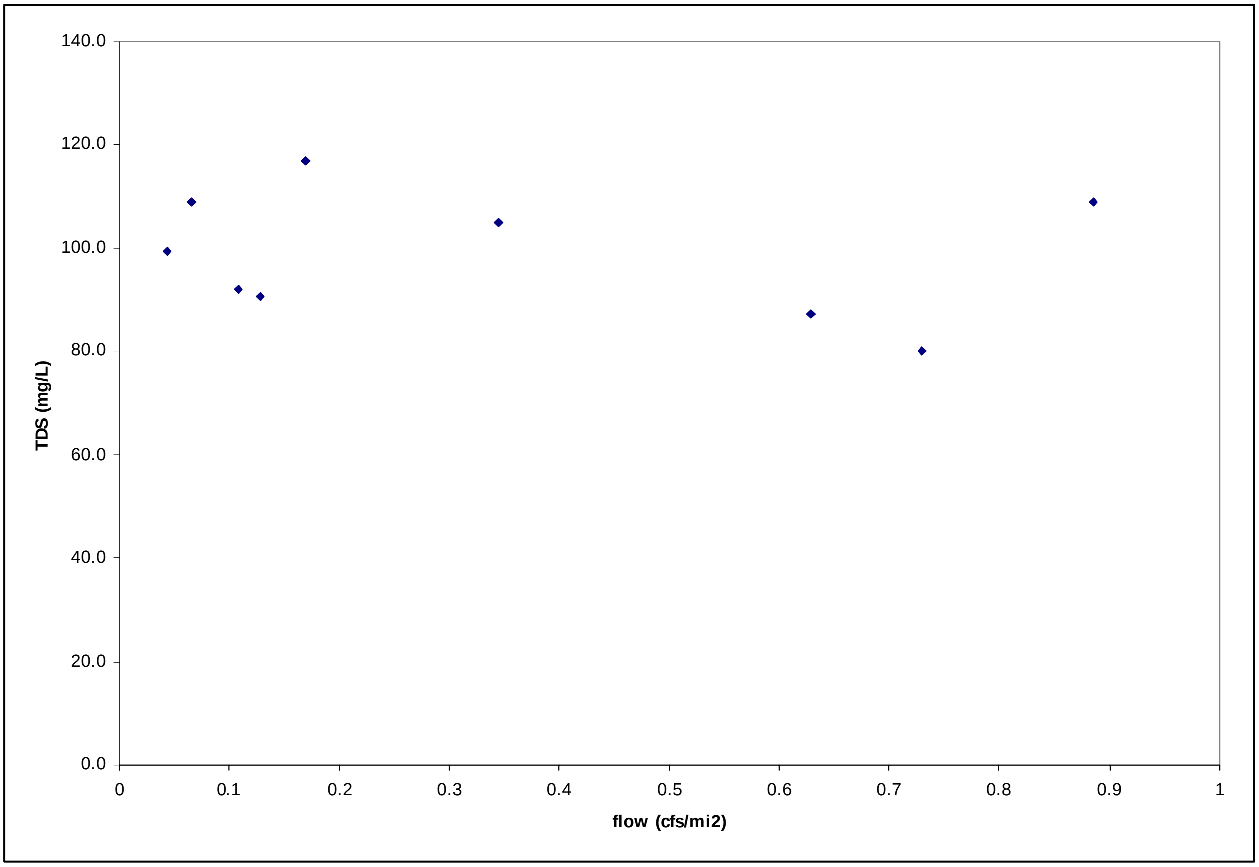

Figure F-29. TDS versus flow at Kisatchie Bayou (subsegment 101103) south of Cypress, Louisiana (station 1218).

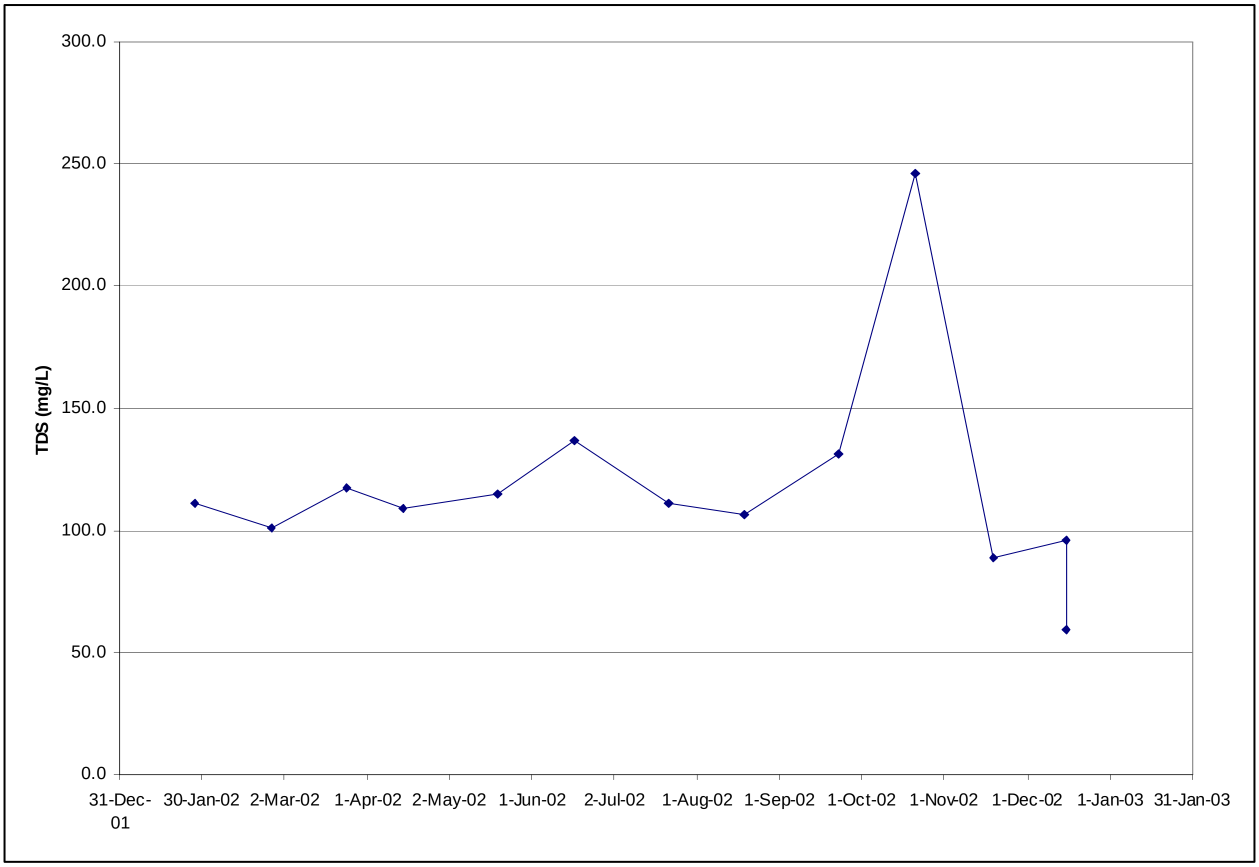

Figure F-30. TDS observations at Iatt Creek (subsegment 101303) southeast of Iatt, Louisiana (station 1222).

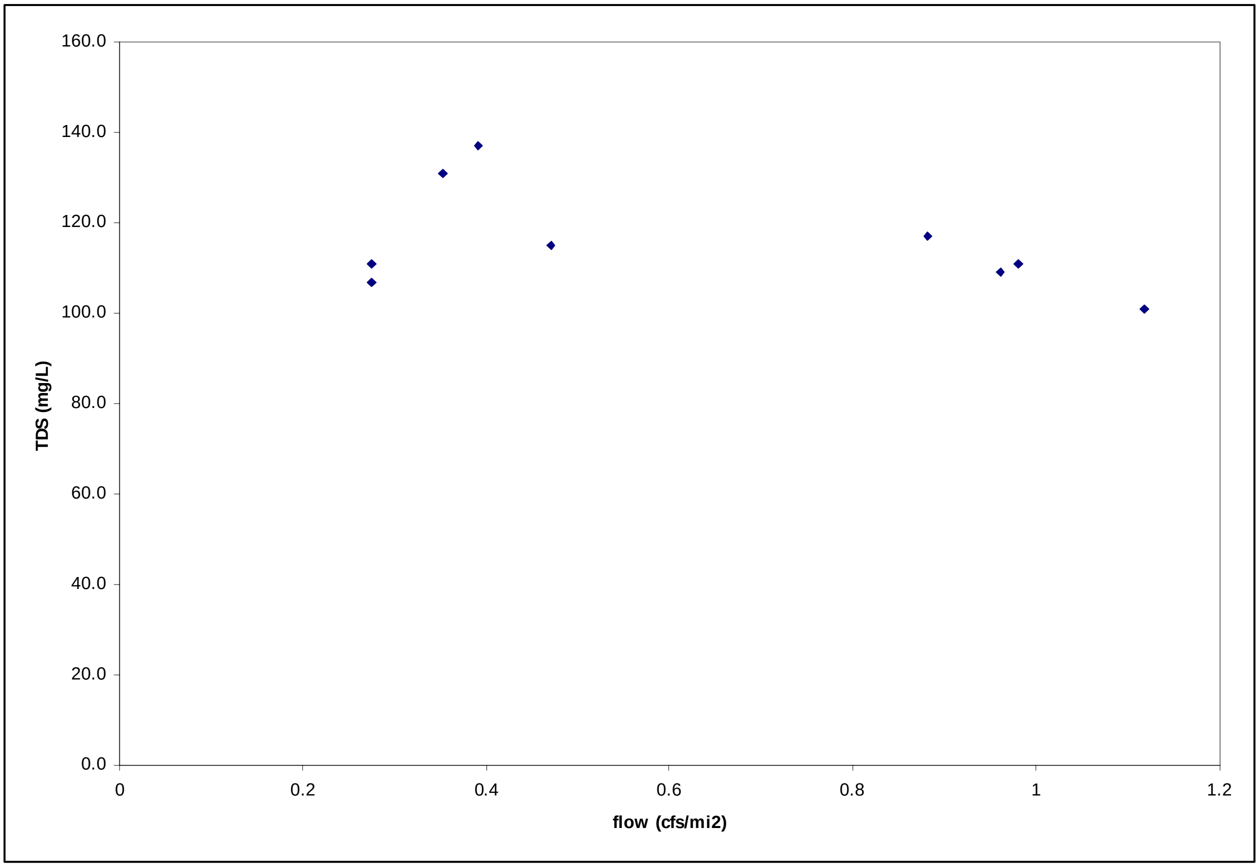

Figure F-31. TDS versus flow at Iatt Creek (subsegment 101303) southeast of Iatt, Louisiana (station 1222).

Appendix G
Turbidity Figures for Red River Basin

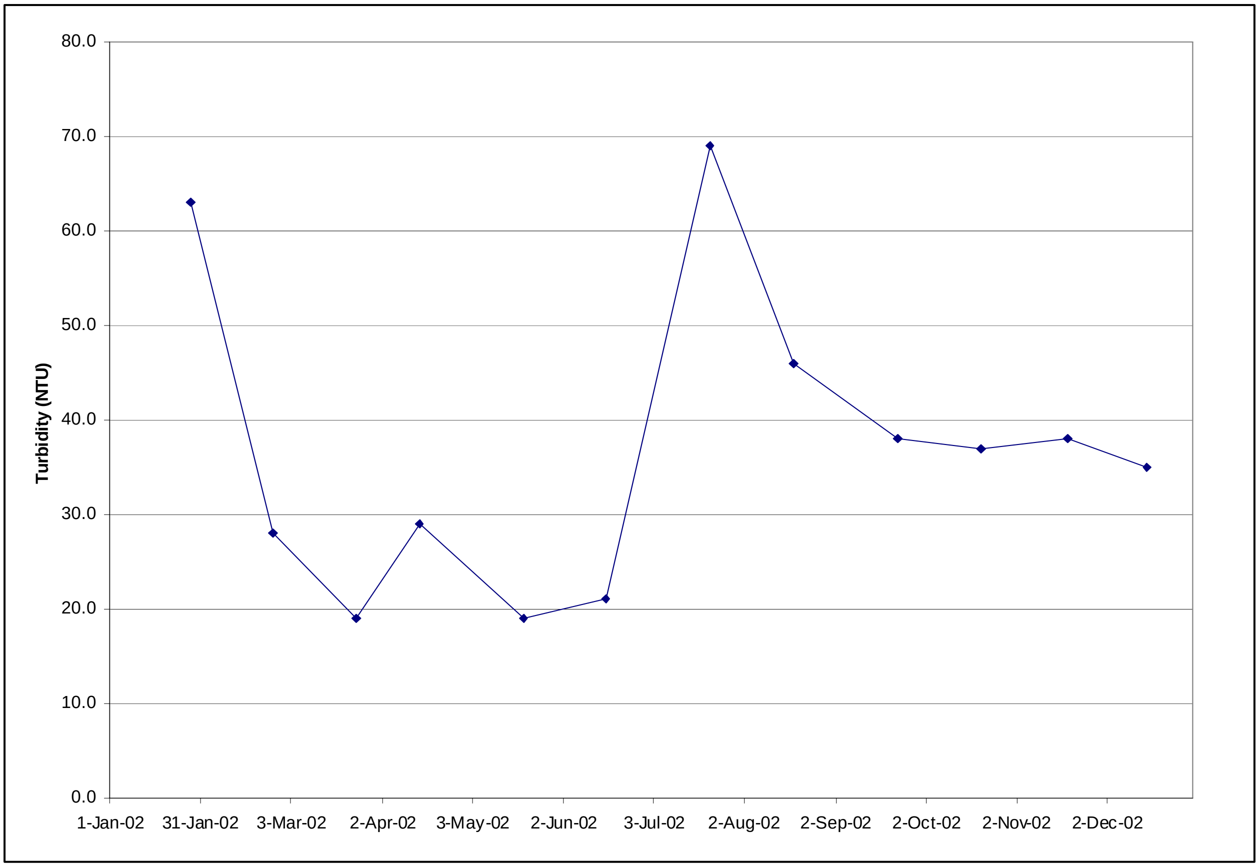

Figure G-1. Turbidity observations at Buhlow Lake (subsegment 101401) northwest of Pineville, Louisiana (station 1223).

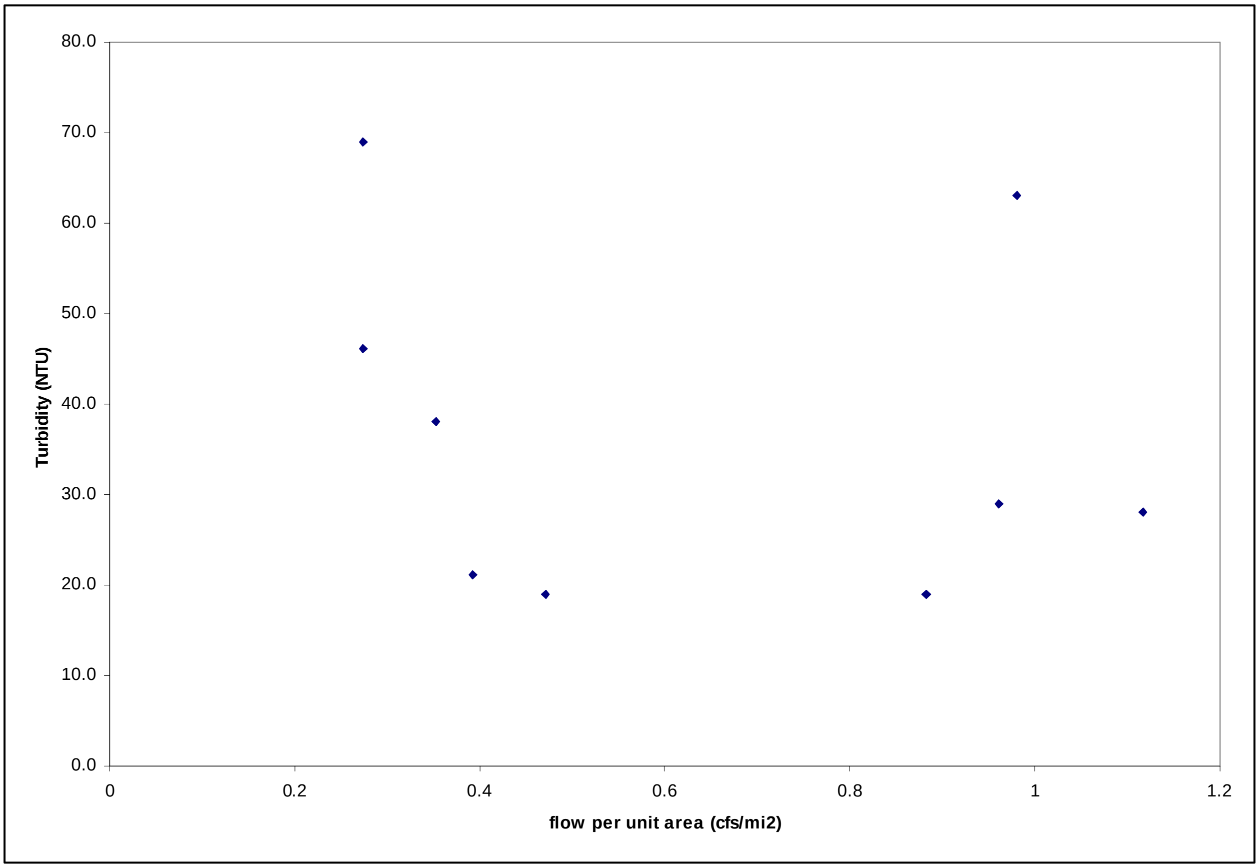

Figure G-2. Turbidity versus flow at Buhlow Lake (subsegment 101401) northwest of Pineville, Louisiana (station 1223).

Appendix I
Red River Basin Load Duration Curve and Plot for TSS

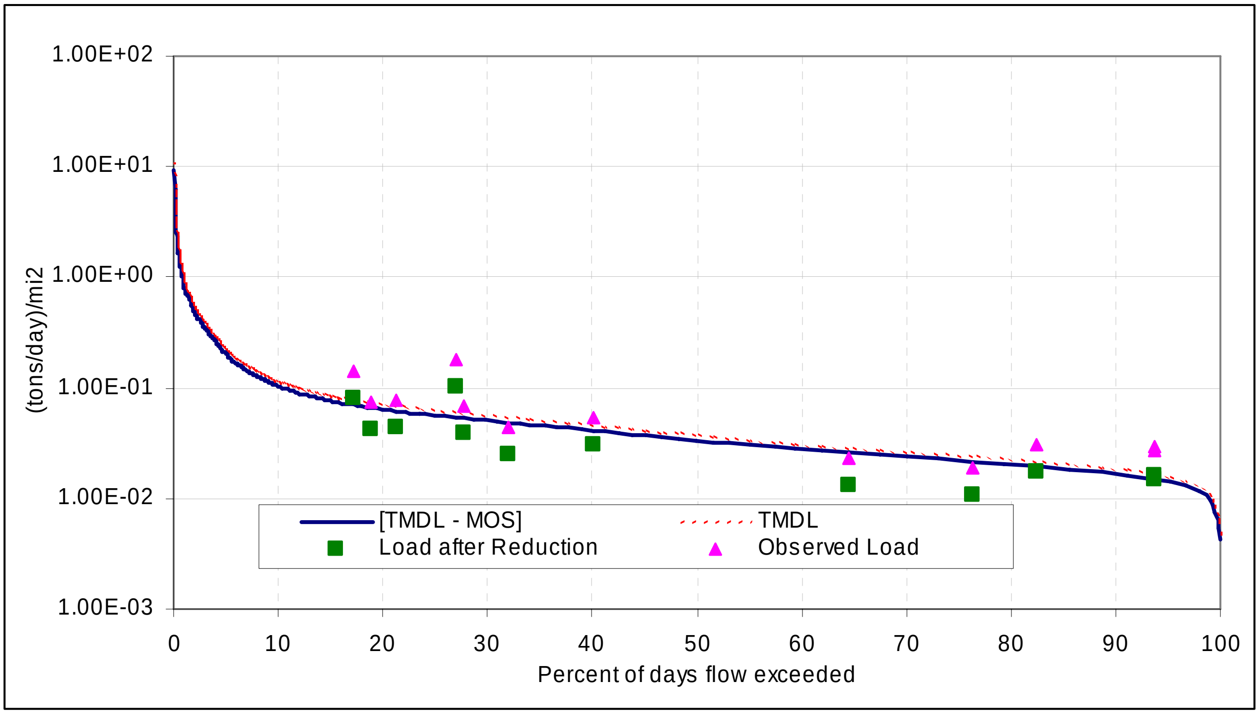

Figure I-1. TSS load duration curve for Buhlow Lake (subsegment 101401) northwest of Pineville, Louisiana (station 1223).

Appendix J
Red River Basin Load Duration Curves and Plots for Chloride

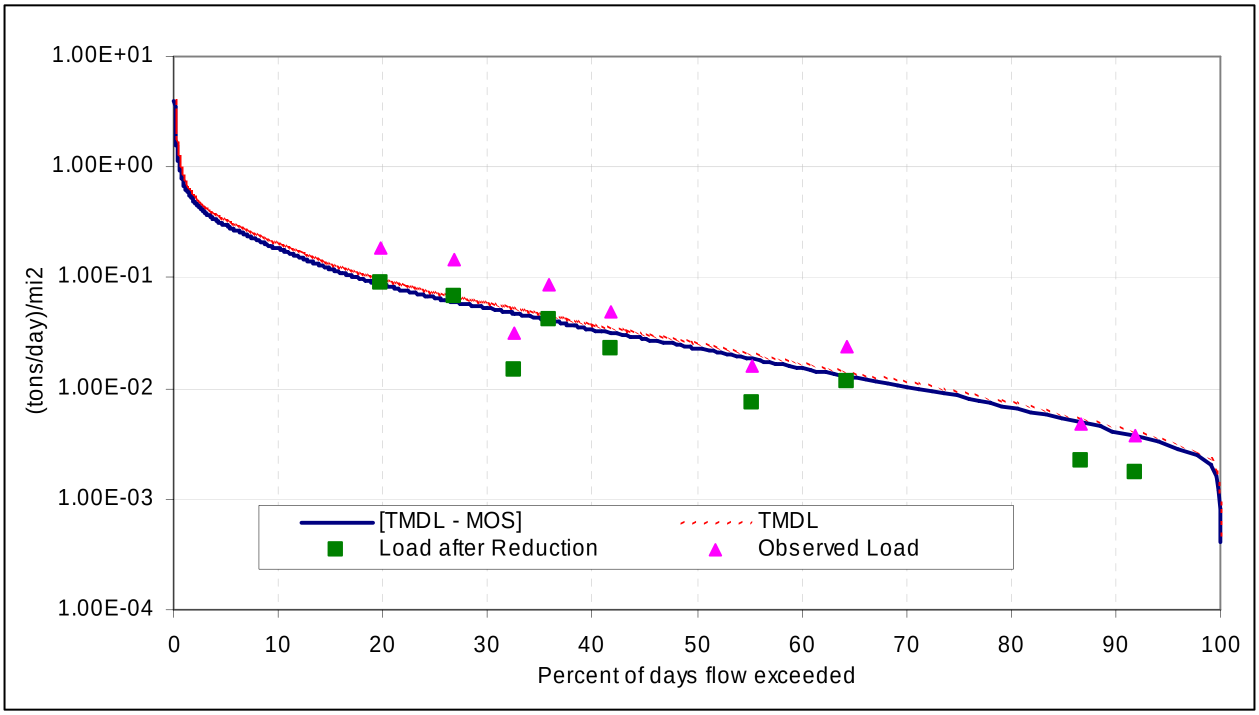

Figure J-1. Chloride load duration curve for unnamed tributary of Grand Bayou (subsegment 100710) near Hall Summit, Louisiana (station 1195).

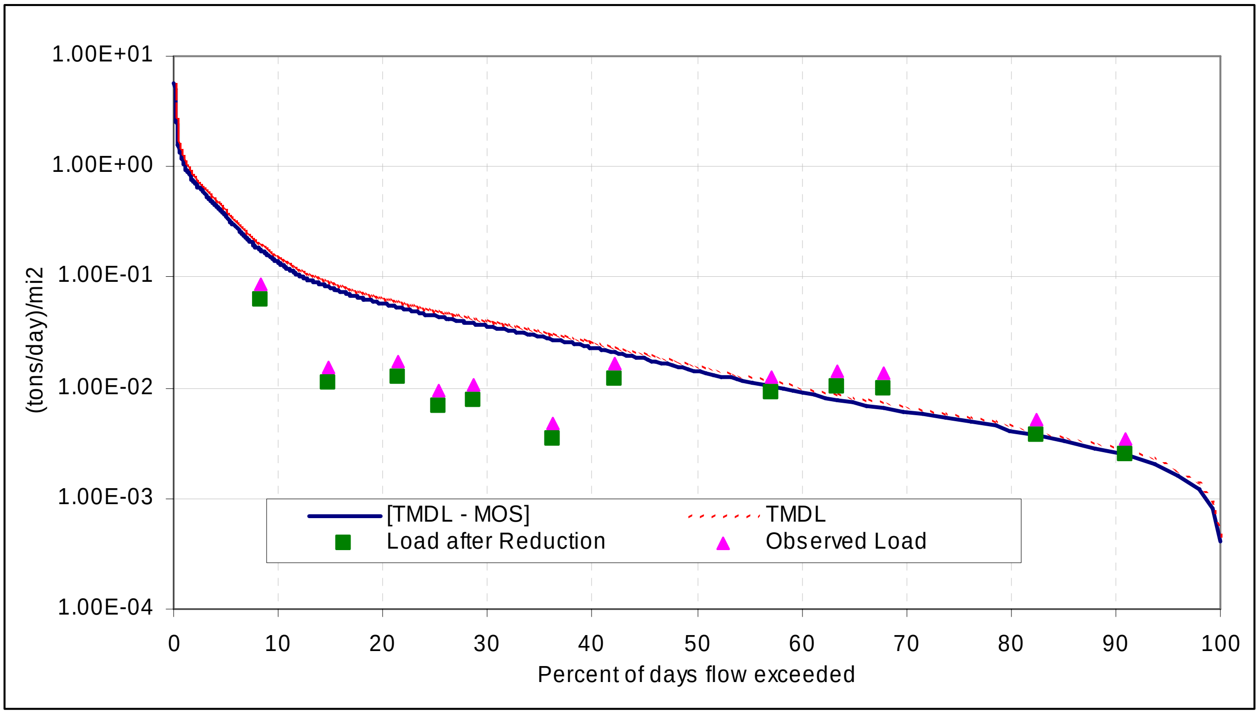

Figure J-2. Chloride load duration curve for Cane River (subsegment 101101) west of Colfax, Louisiana (station 1217).

Appendix K
Red River Basin Load Duration Curves and Plots for Total Dissolved Solids

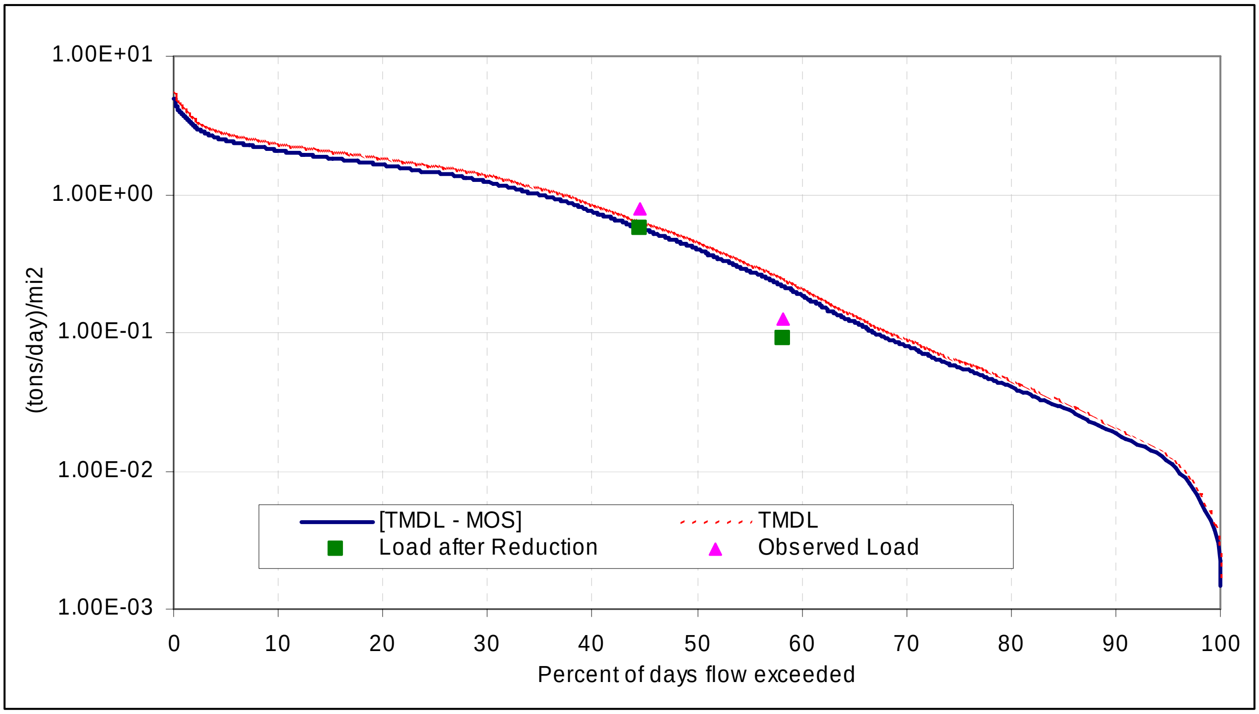

Figure K-1. TDS load duration curve for Flat River Drainage Canal (subsegment 100406) north of Bossier City, Louisiana (station 363).

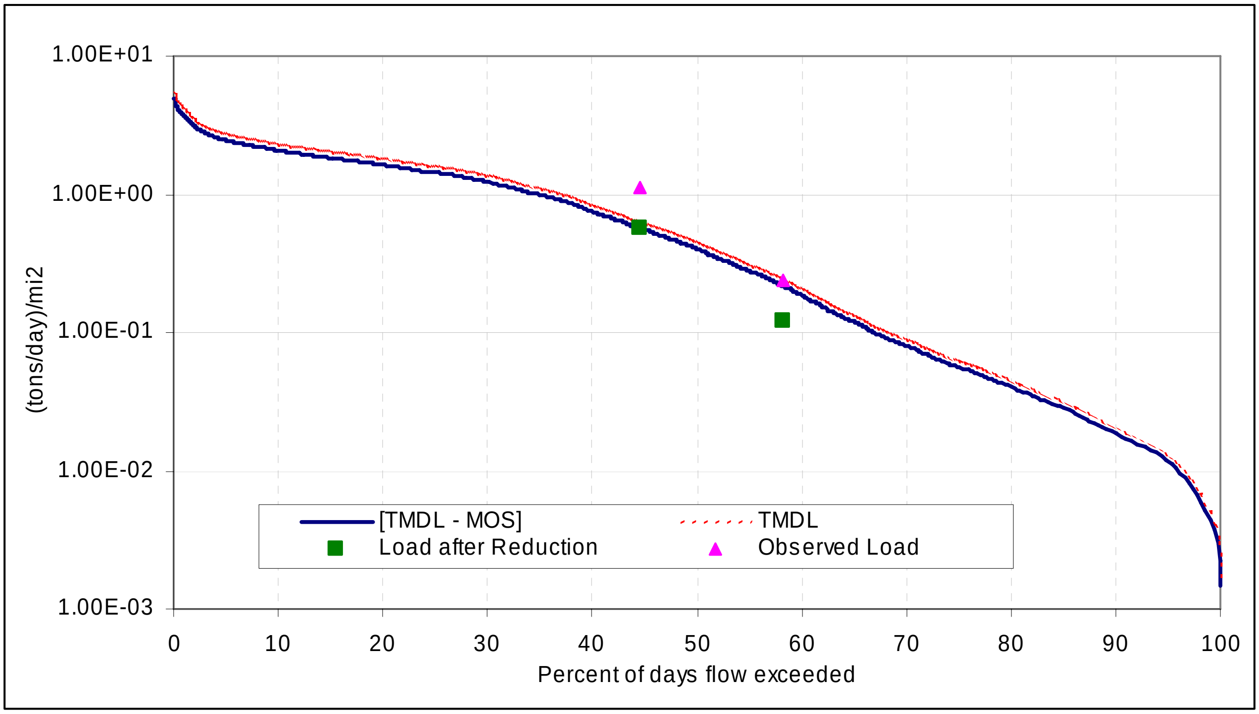

Figure K-2. TDS load duration curve for Flat River Drainage Canal (subsegment 100406) northeast of Bossier City, Louisiana (station 389).

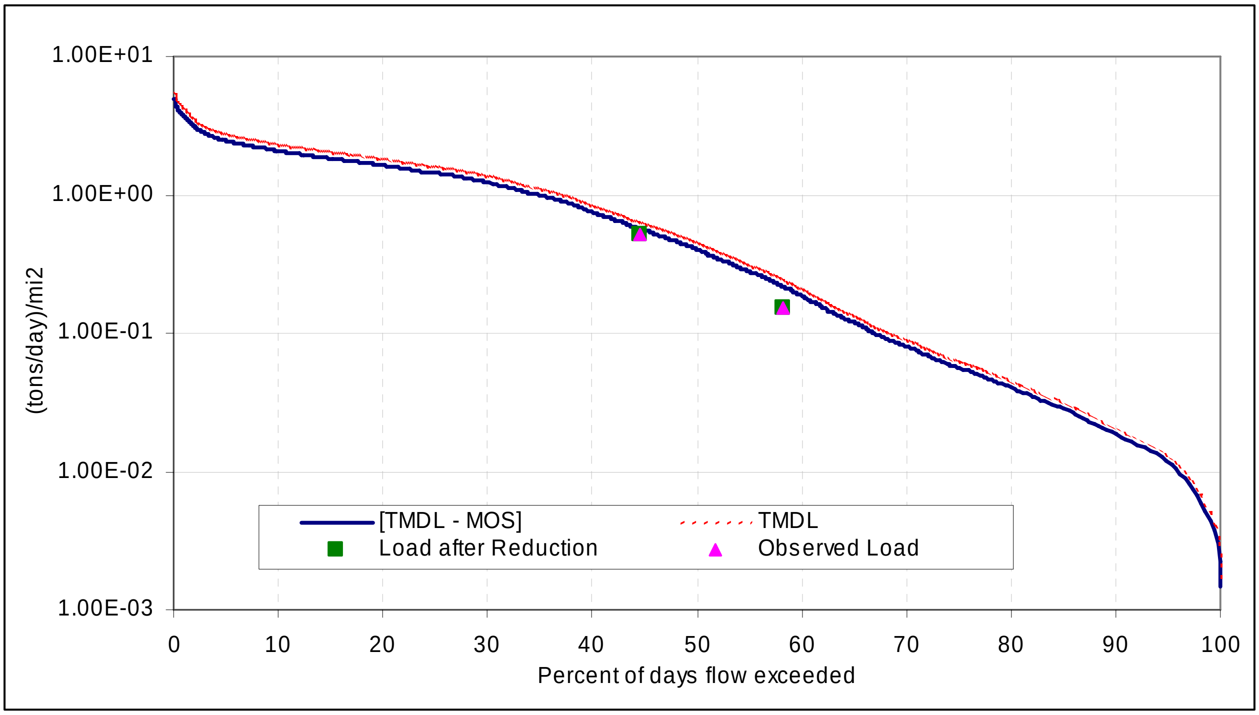

Figure K-3. TDS load duration curve for Flat River Drainage Canal (subsegment 100406) northeast of Shreveport, Louisiana (station 390).

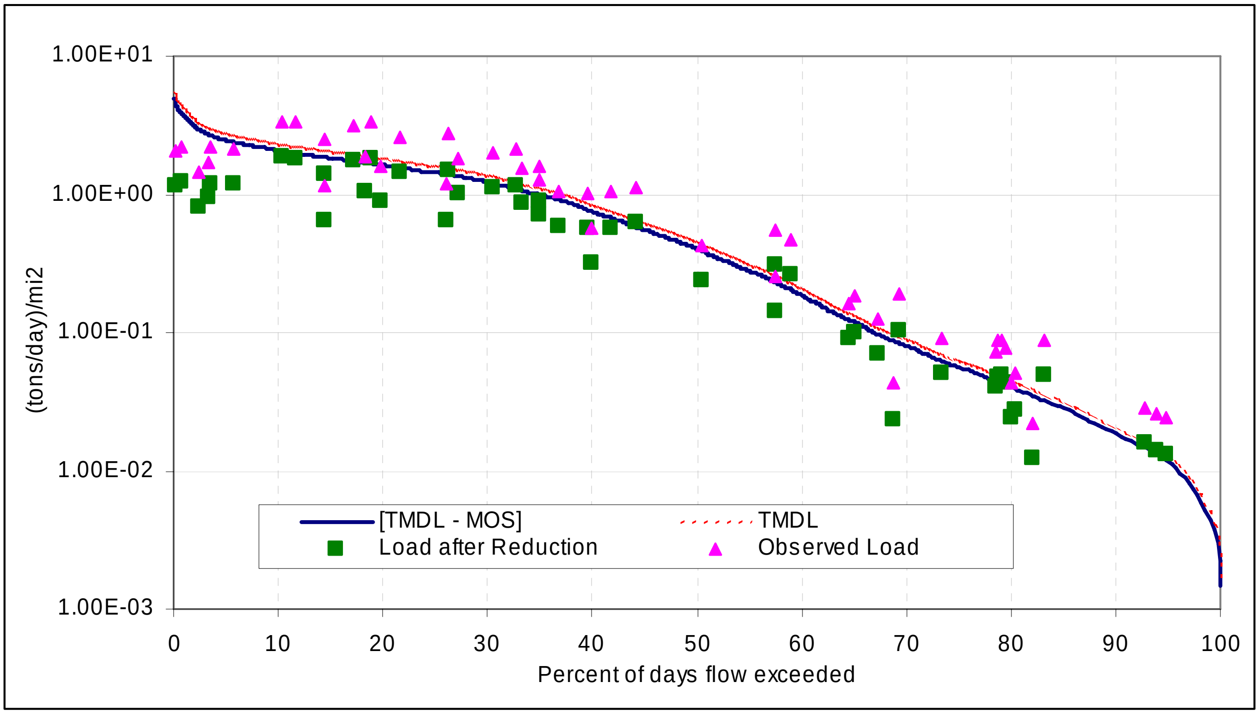

Figure K-4. TDS load duration curve for Flat River (subsegment 100406) east of Taylortown, Louisiana (station 272).

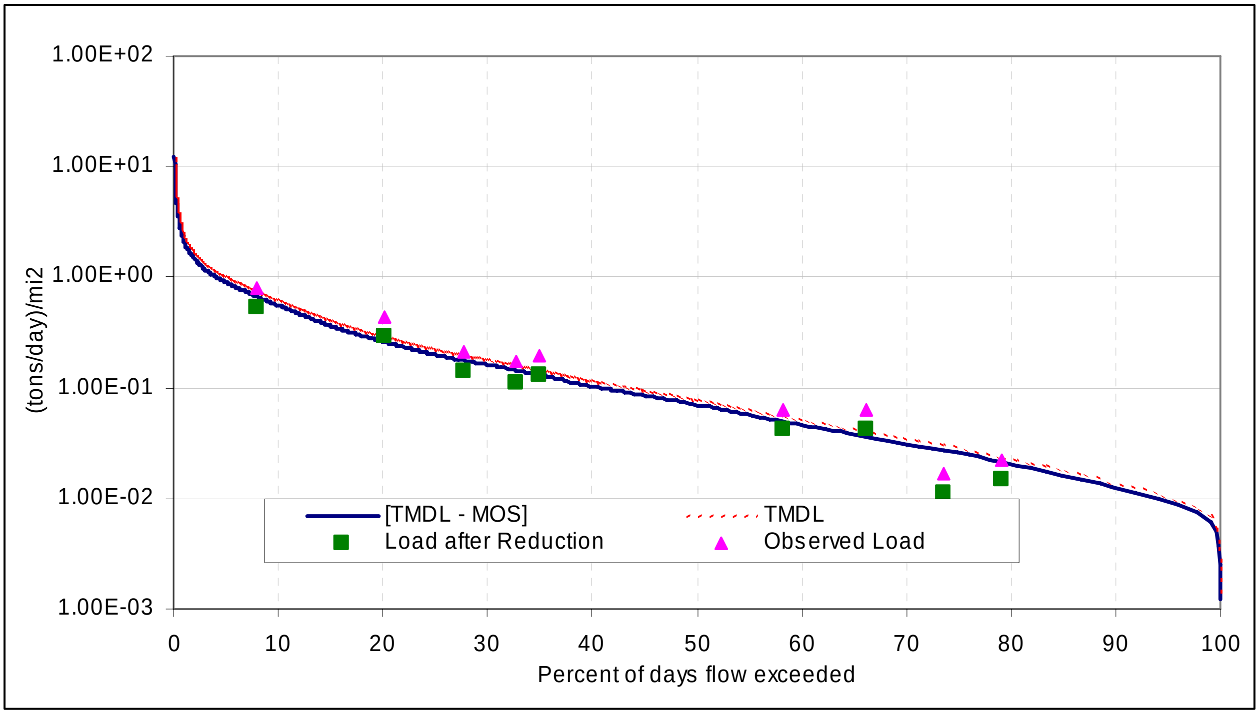

Figure K-5. TDS load duration curve for unnamed tributary of Castor Creek (subsegment 100708) near Castor, Louisiana (station 1194).

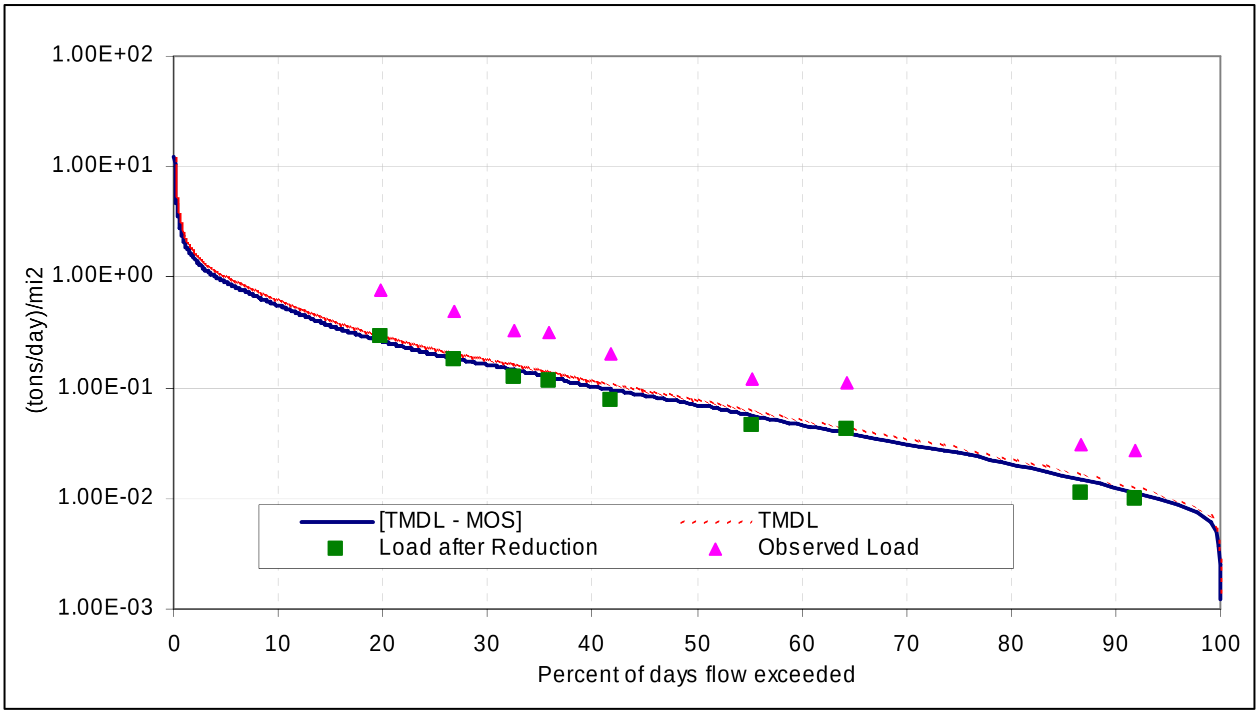

Figure K-6. TDS load duration curve for unnamed tributary of Grand Bayou (subsegment 100710) near Hall Summit, Louisiana (station 1195).

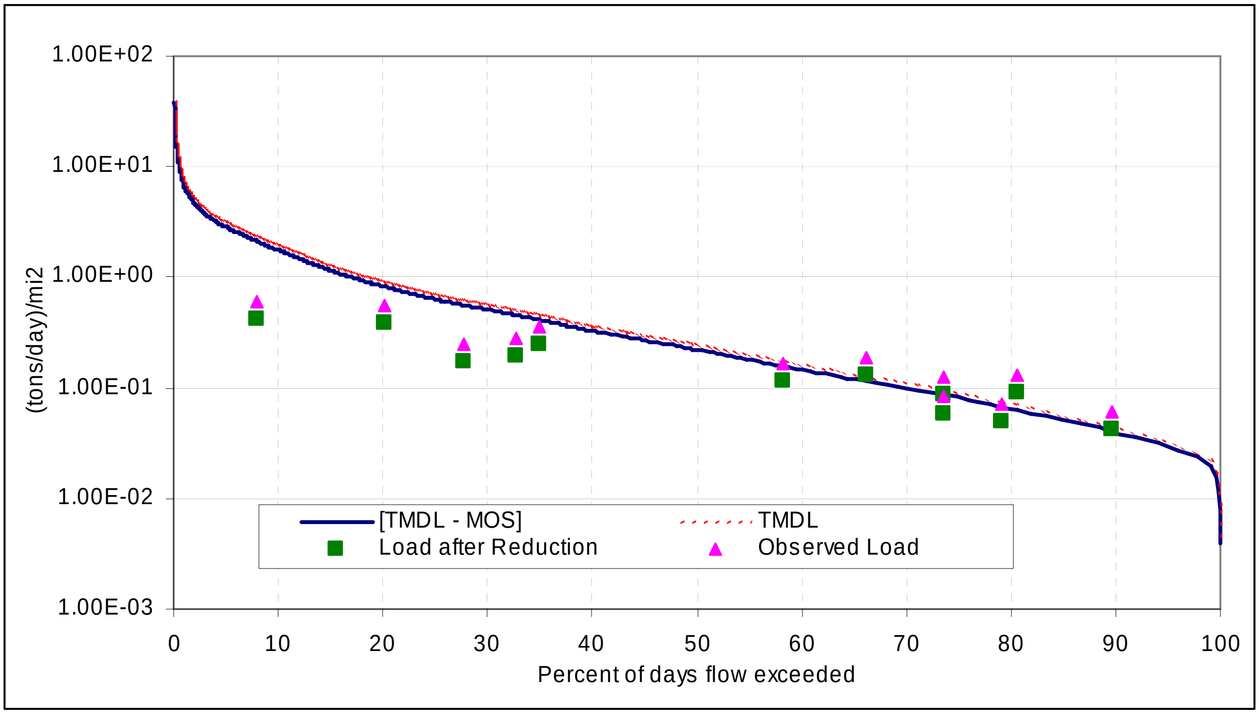

Figure K-7. TDS load duration curve for unnamed tributary of Saline Bayou (subsegment 100804) near Arcadia, Louisiana (station 1206).

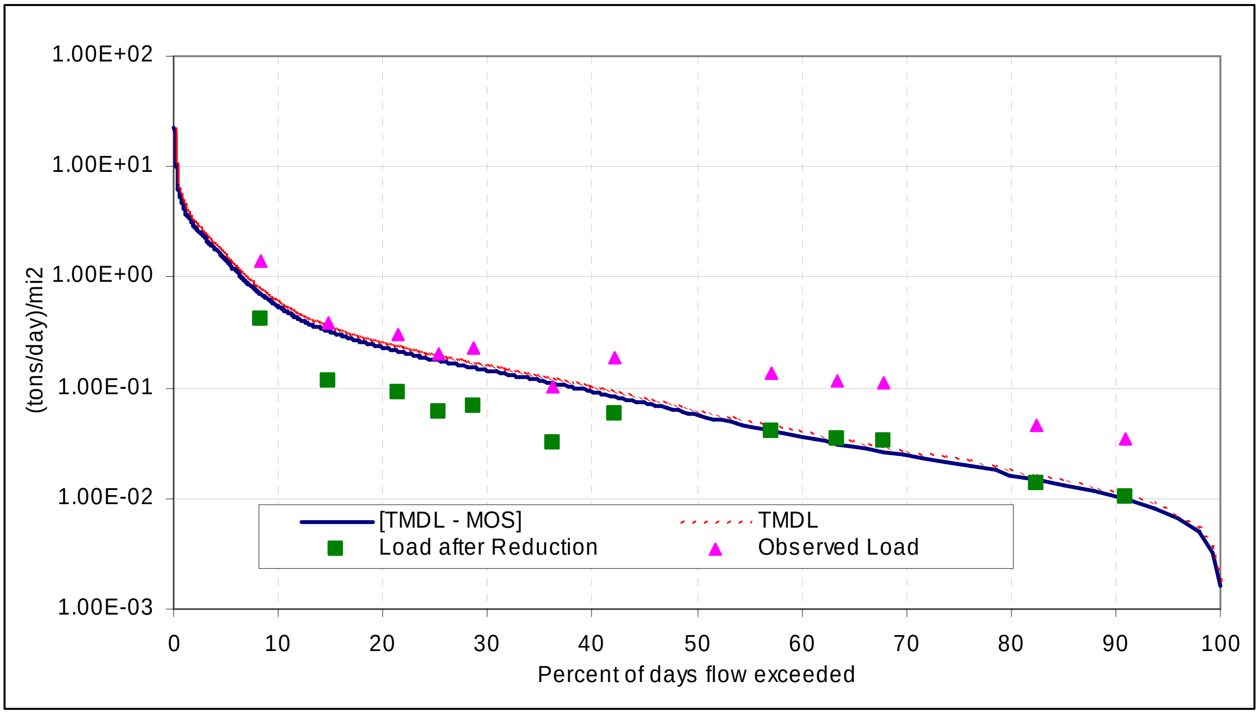

Figure K-8. TDS load duration curve for Cane River (subsegment 101101) west of Colfax, Louisiana (station 1217).

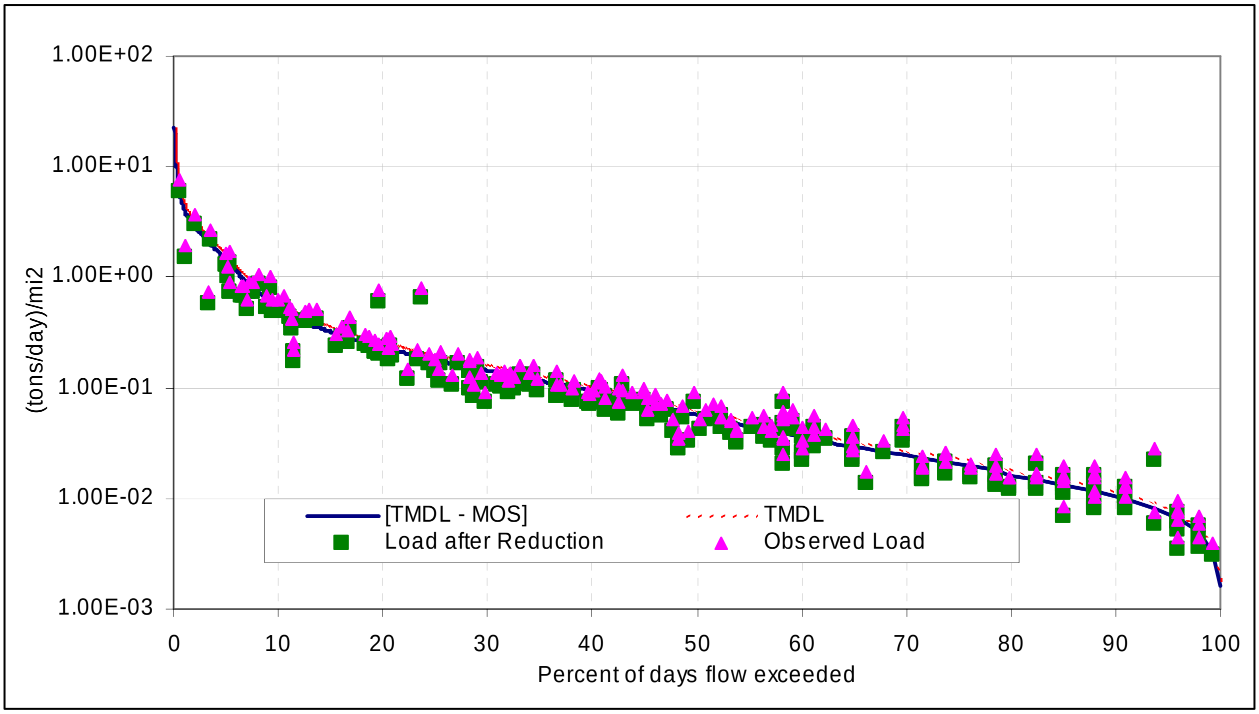

Figure K-9. TDS load duration curve for Kisatchie Bayou (subsegment 101103) near Lotus, Louisiana (station 42).

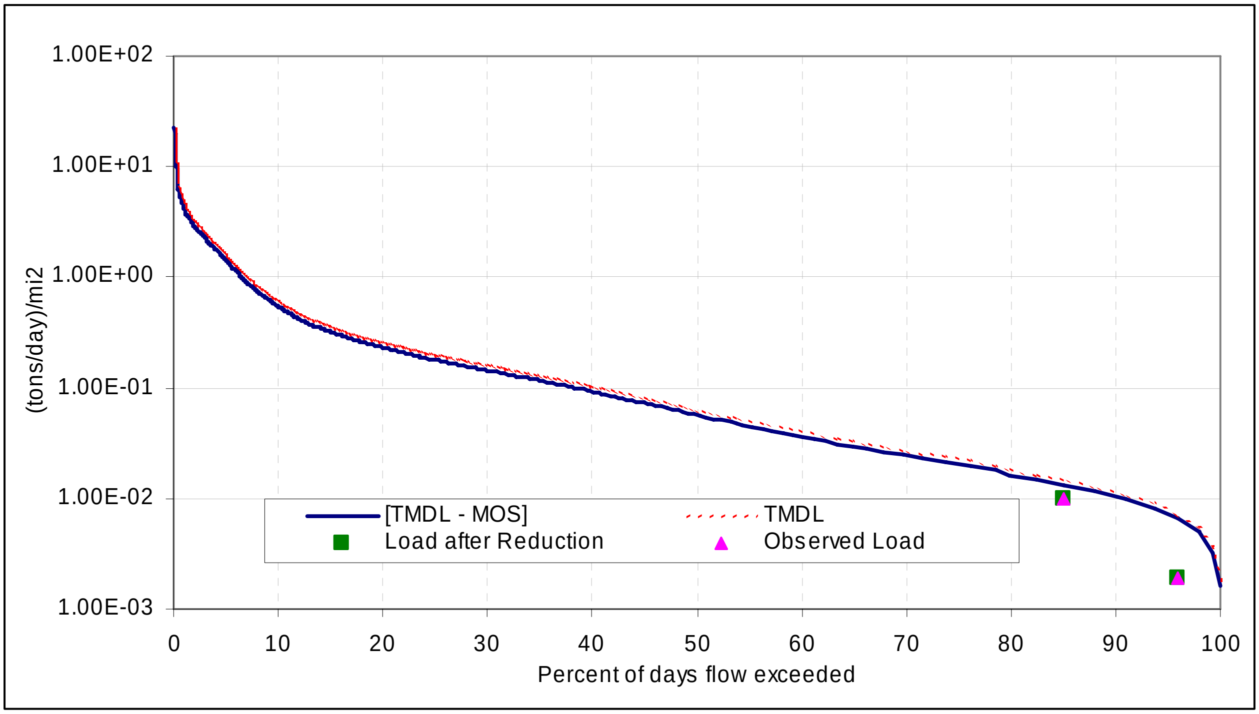

Figure K-10. TDS load duration curve for Little Sandy Creek (subsegment 101103) at Kisatchie, Louisiana (station 550).

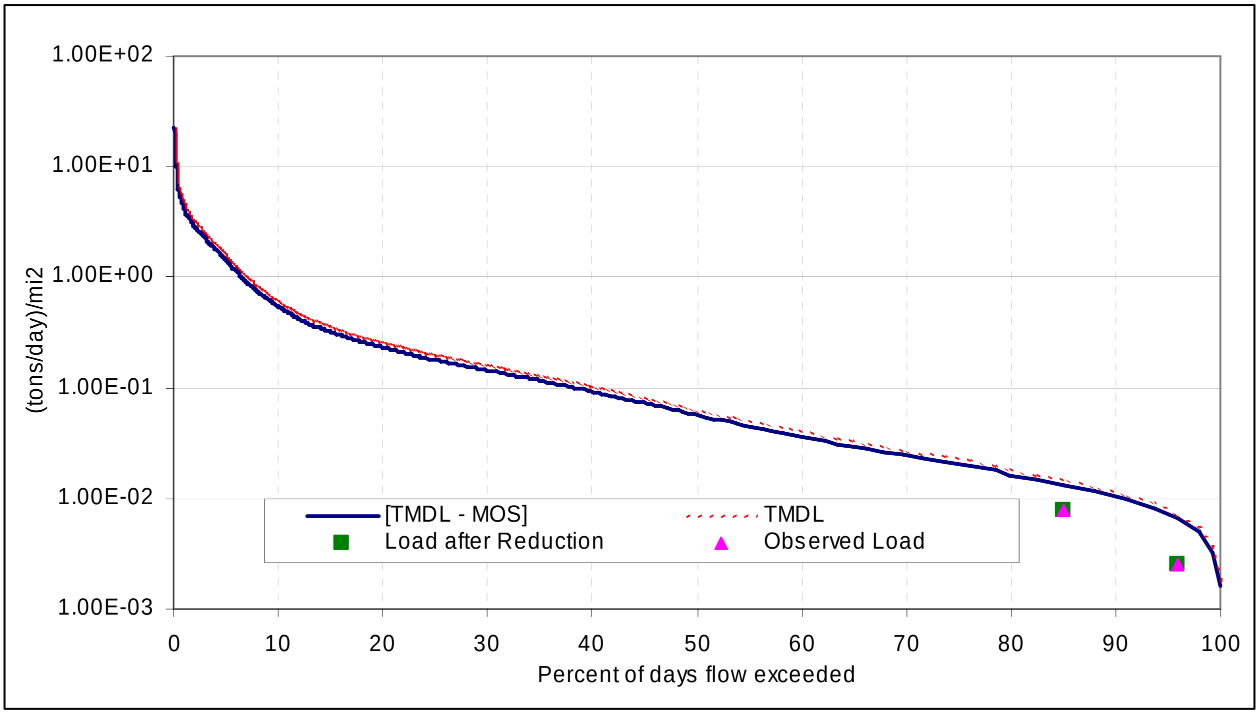

Figure K-11. TDS load duration curve for Kisatchie Bayou (subsegment 101103) at Kisatchie, Louisiana (station 549).

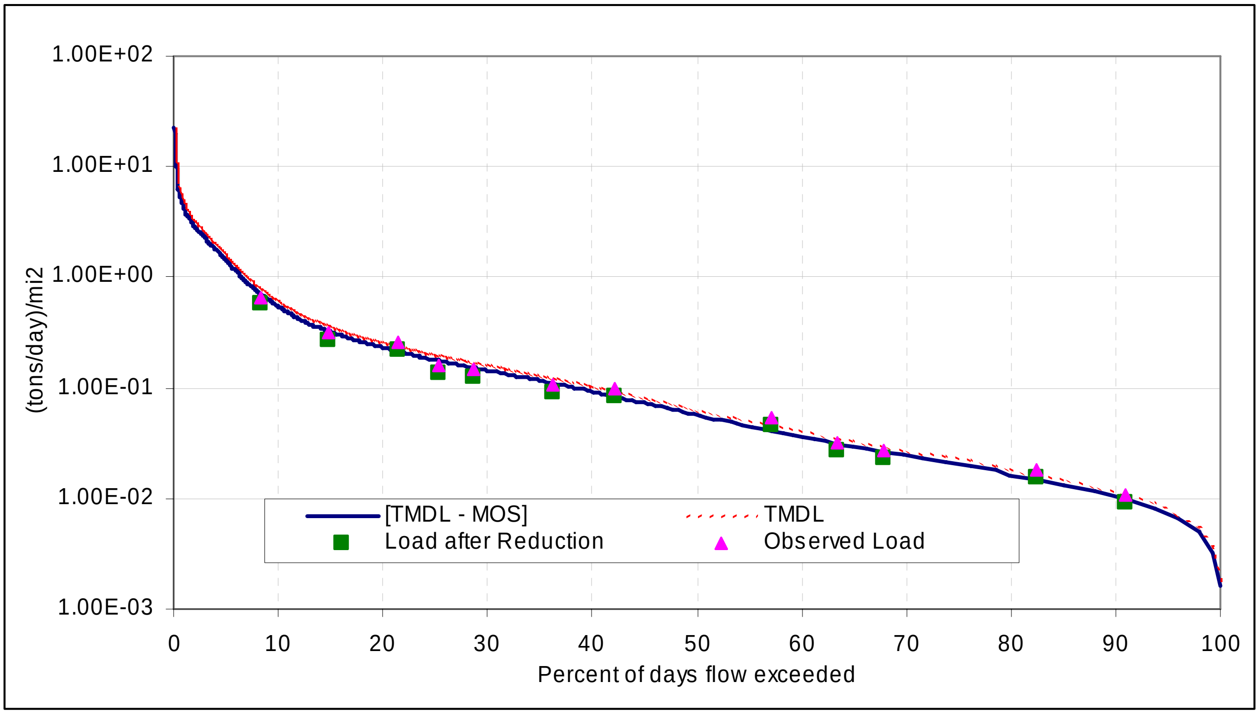

Figure K-12. TDS load duration curve for Kisatchie Bayou (subsegment 101103) south of Cypress, Louisiana (station 1218).

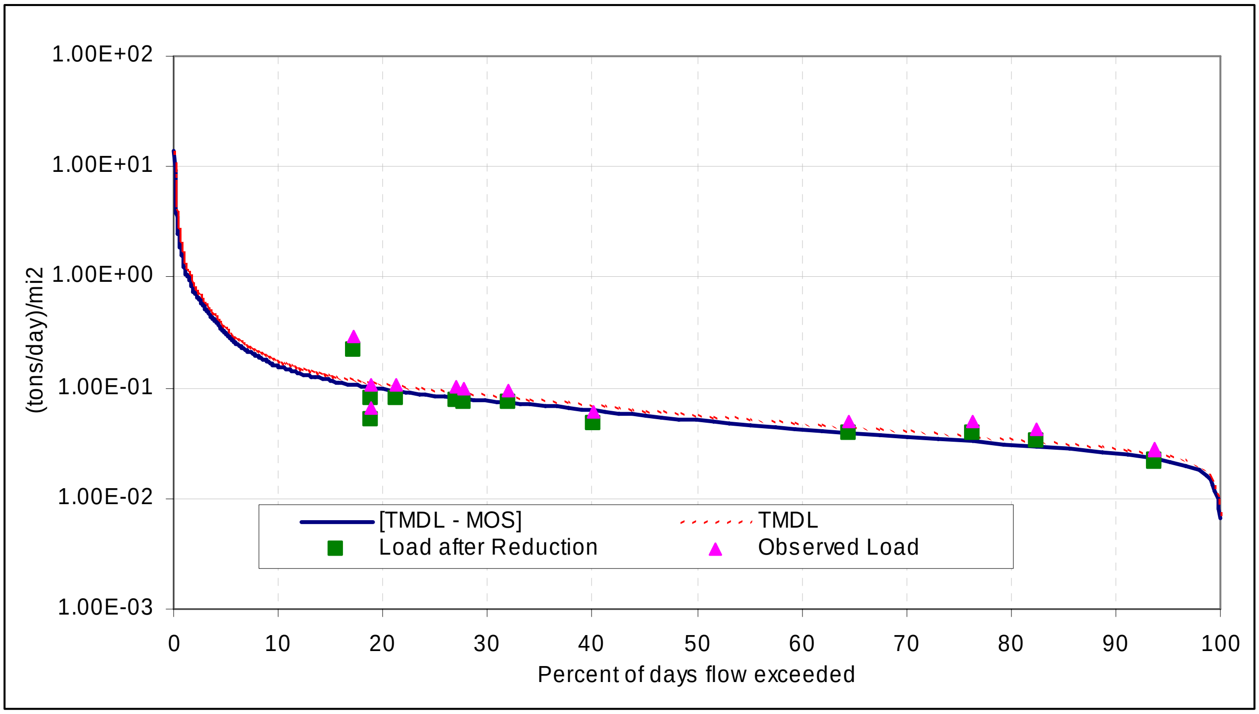

Figure K-13. TDS load duration curve for Iatt Creek (subsegment 101303) southeast of Iatt, Louisiana (station 1222).

Appendix L
Red River Basin Load Duration Curves and Plots for Sulfate

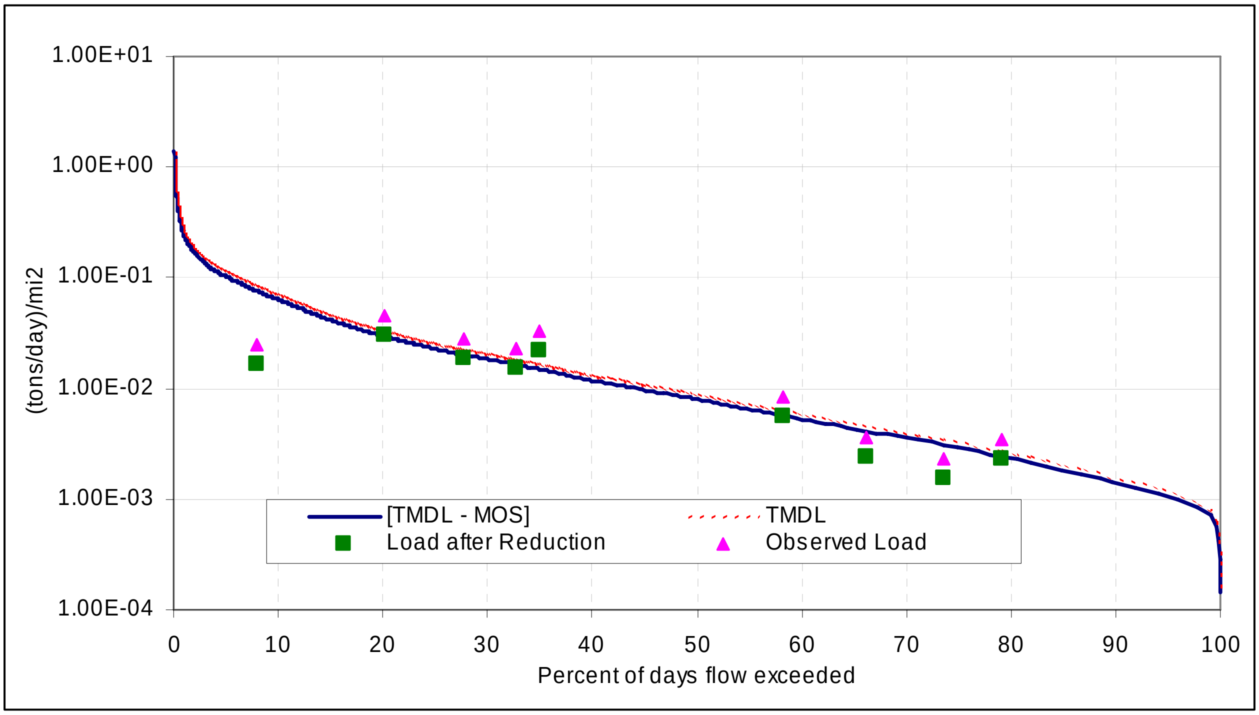

Figure L-1. Sulfate load duration curve for unnamed tributary of Castor Creek (subsegment 100708) near Castor, Louisiana (station 1194).

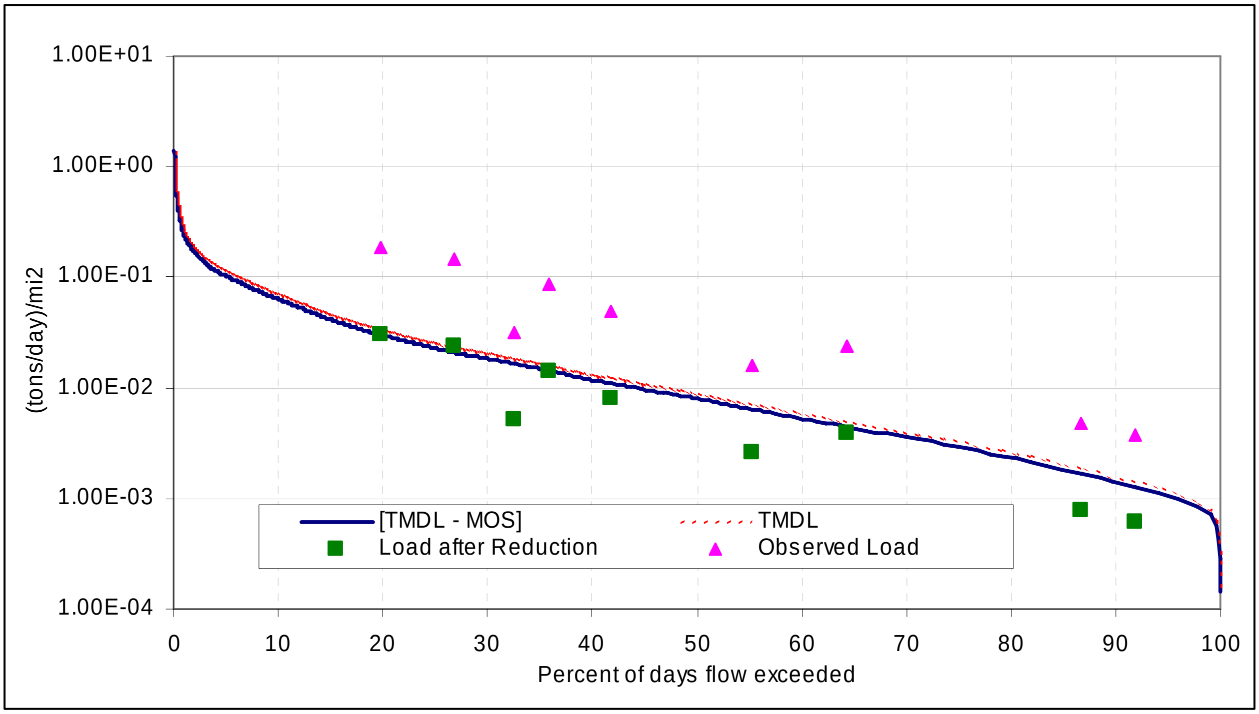

Figure L-2. Sulfate load duration curve for unnamed tributary of Grand Bayou (subsegment 100710) near Hall Summit, Louisiana (station 1195).

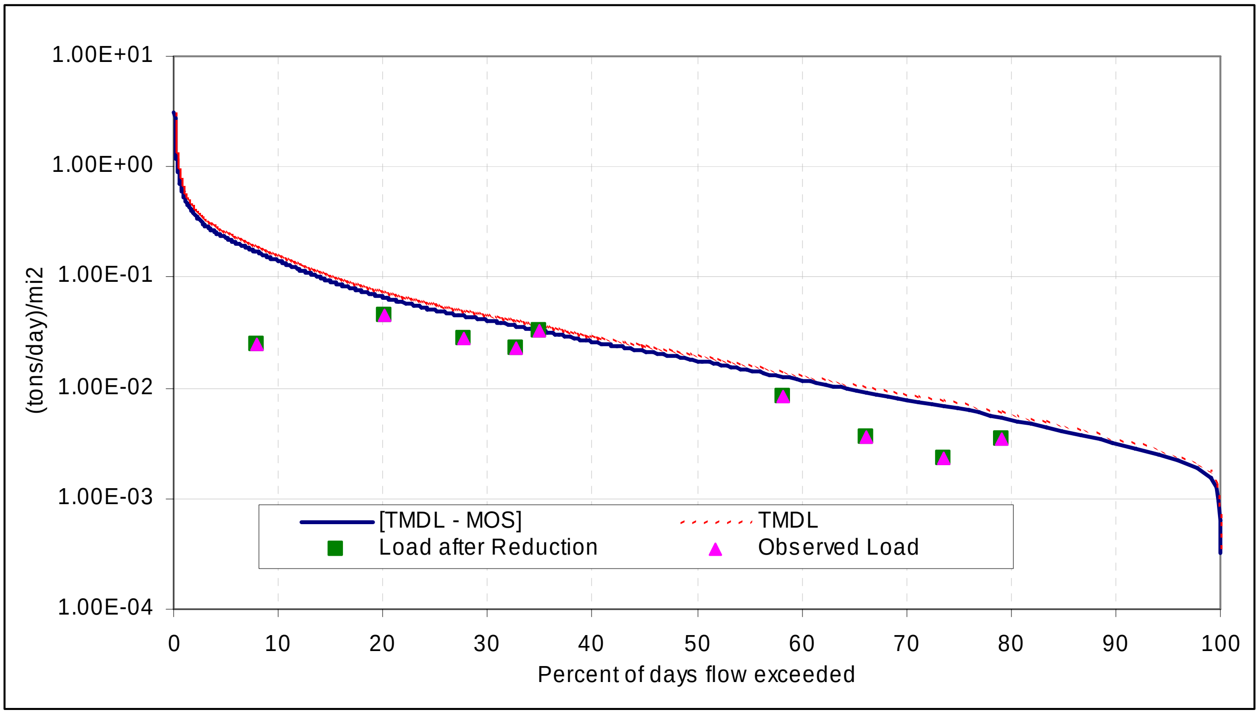

Figure L-3. Sulfate load duration curve for unnamed tributary of Saline Bayou (subsegment 100804) near Arcadia, Louisiana (station 1206).

Appendix M
Red River Basin Load Duration Curves and Plots for Fecal Coliform Bacteria: Summer

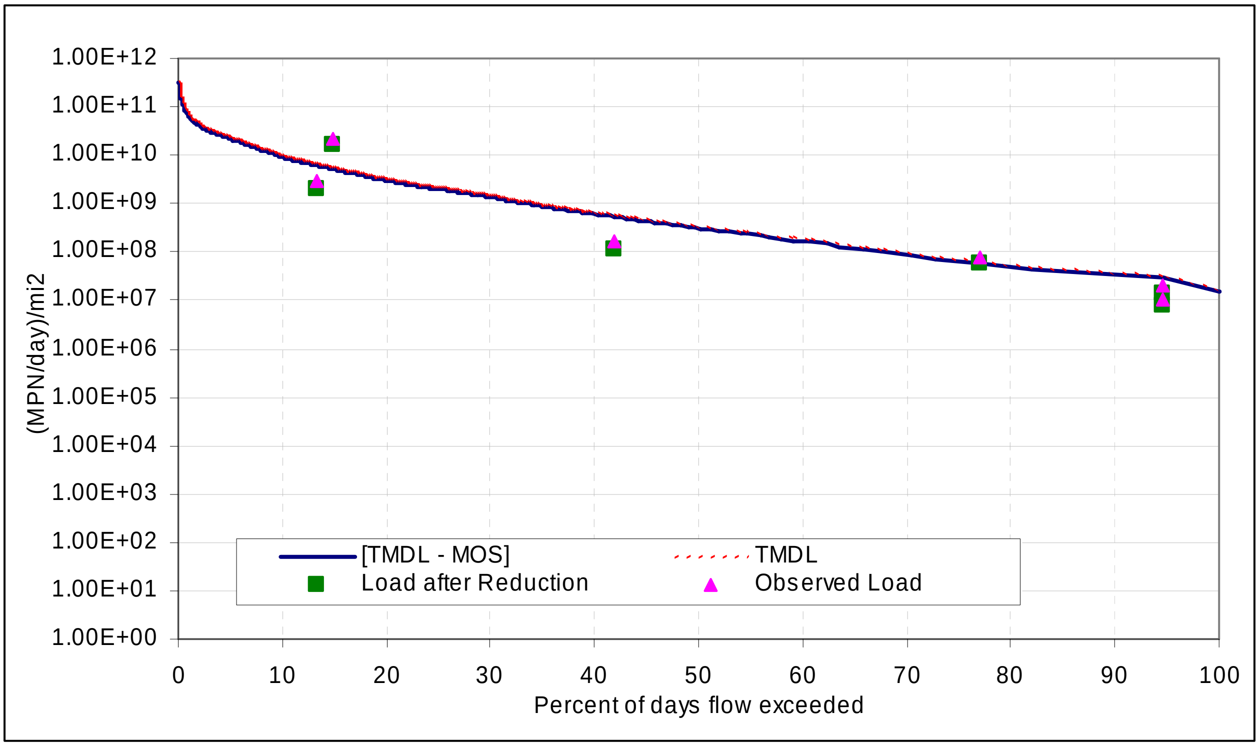

Figure M-1. Summer fecal coliform bacteria load duration curve for Kelly Bayou (subsegment 100306) at Huckaby Road, south of Hosston, Louisiana (station 1192).

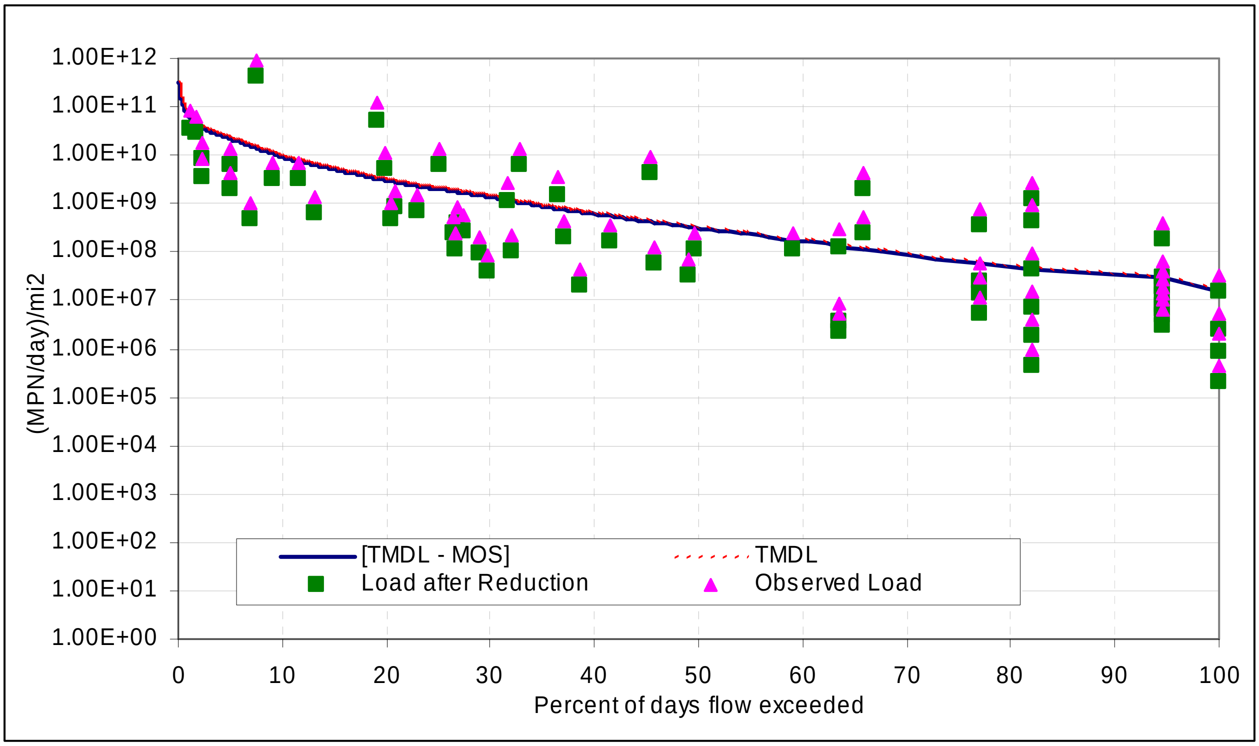

Figure M-2. Summer fecal coliform bacteria load duration curve for Kelly Bayou (subsegment 100306) near Hosston, Louisiana (station 56).

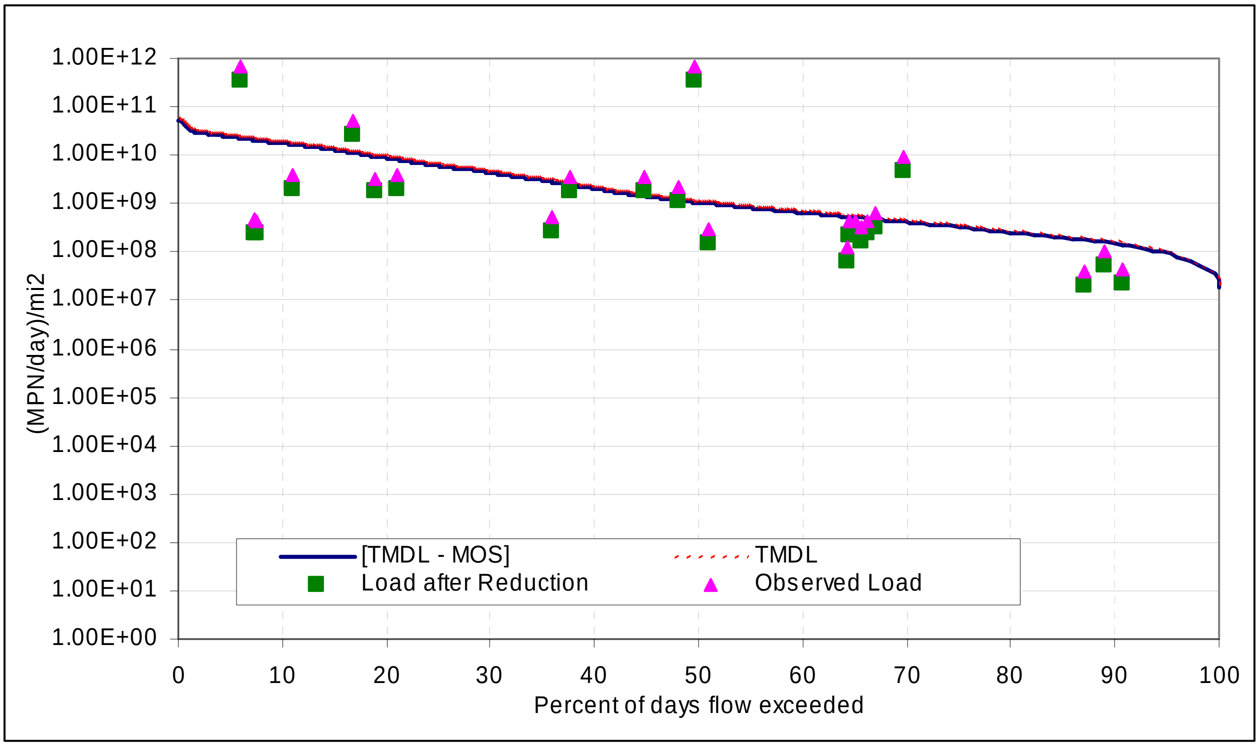

Figure M-3. Summer fecal coliform bacteria load duration curve for Flat River (subsegment 100406) east of Taylortown, Louisiana (station 272).

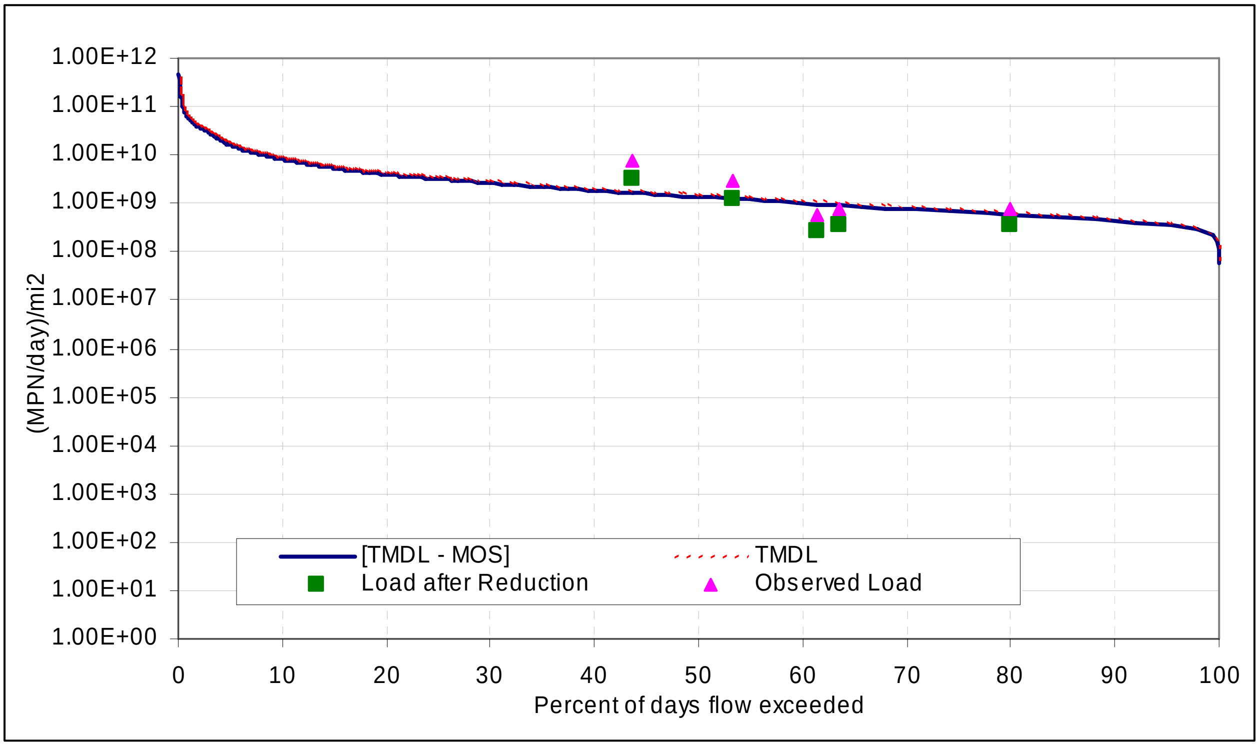

Figure M-4. Summer fecal coliform bacteria load duration curve for Castor Creek (subsegment 100707) at Highway 507, southwest of Castor, Louisiana (station 1189).

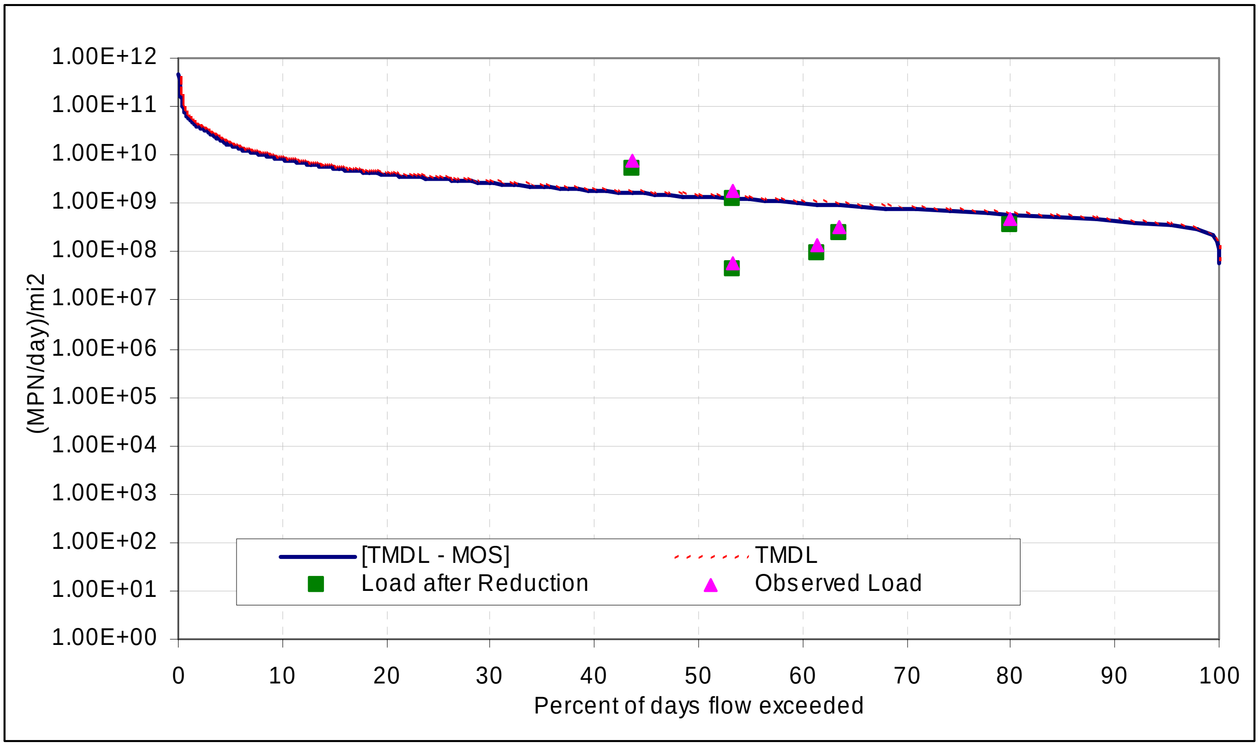

Figure M-5. Summer fecal coliform bacteria load duration curve for Grand Bayou (subsegment 100709) at Highway 507, north of Fairview Alpha, Louisiana (station 1190).

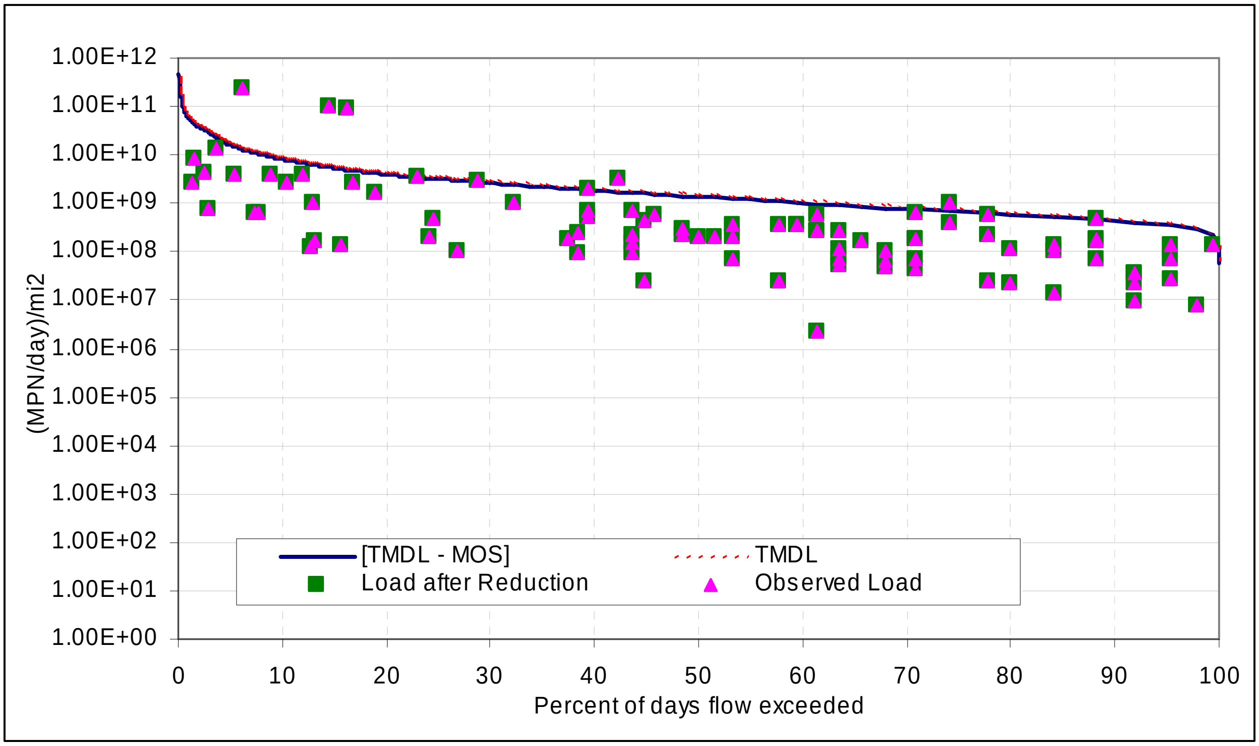

Figure M-6. Summer fecal coliform bacteria load duration curve for Saline Bayou (subsegment 100801) near Goldonna, Louisiana (station 75).

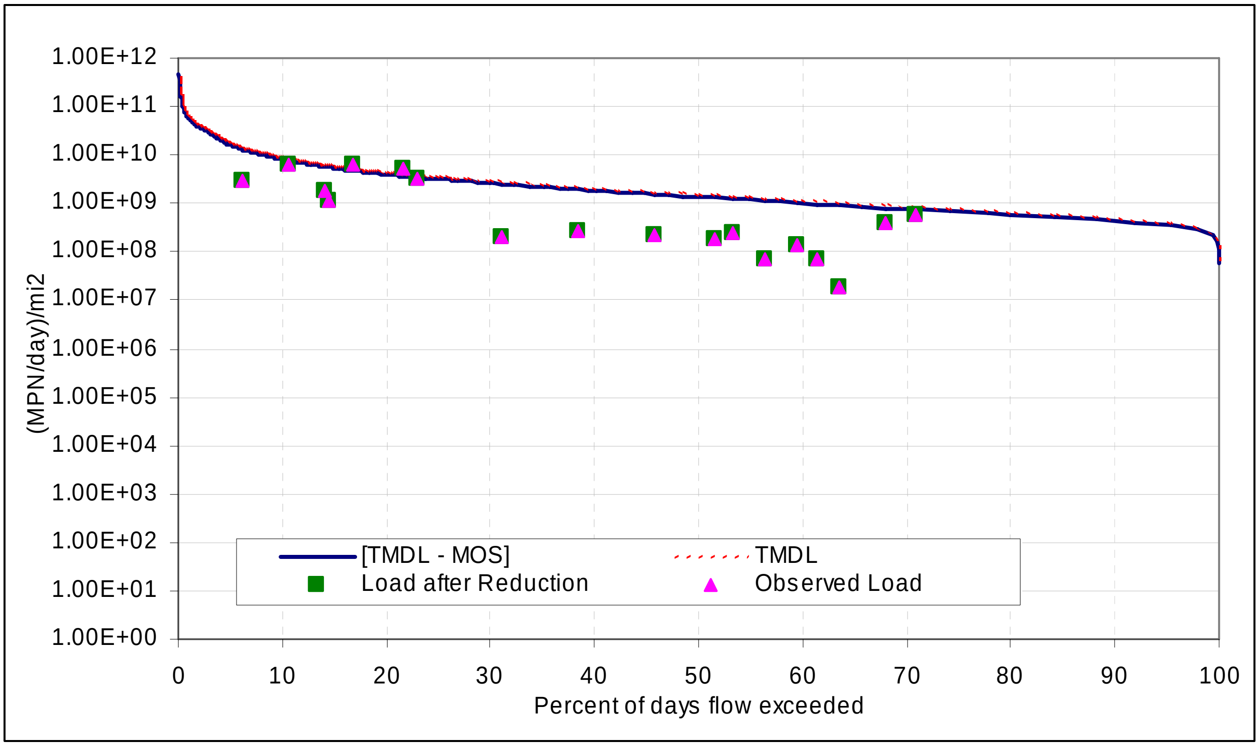

Figure M-7. Summer fecal coliform bacteria load duration curve for Saline Bayou (subsegment 100801) east of Bienville, Louisiana (station 284).

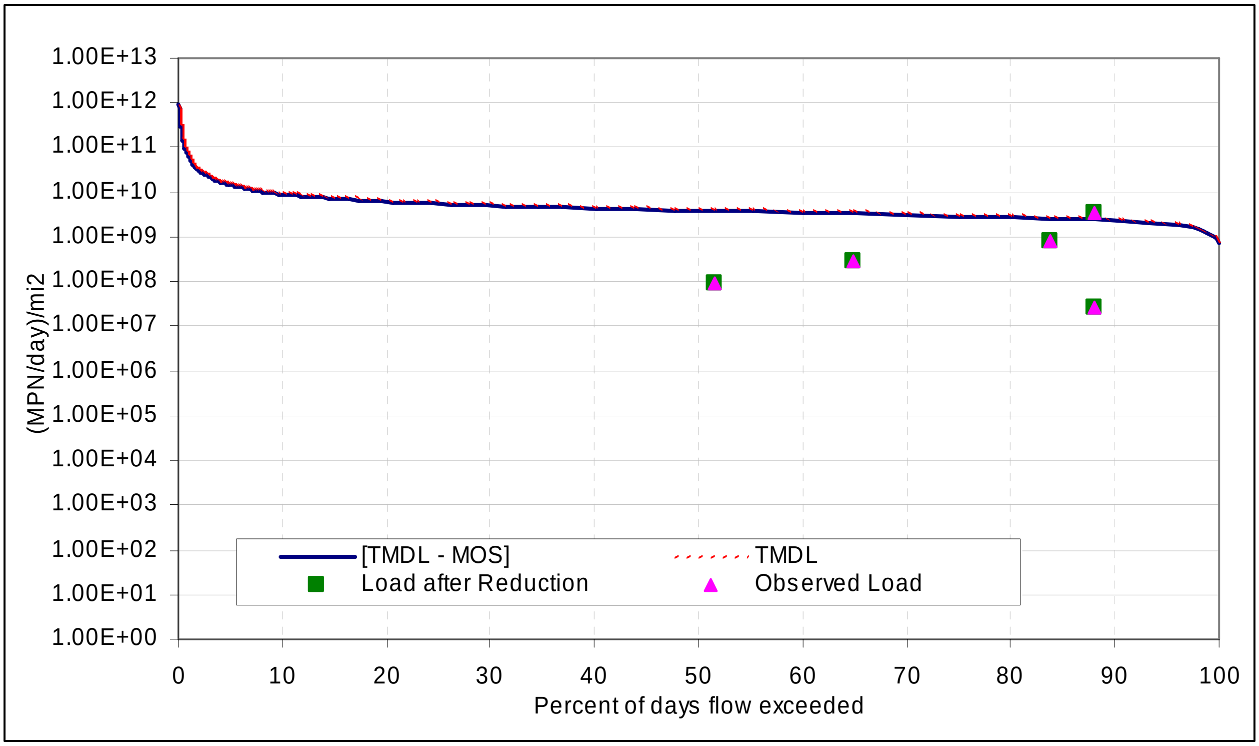

Figure M-8. Summer fecal coliform bacteria load duration curve for Rigolette Bayou (subsegment 100901) northwest of Pineville, Louisiana (station 1220).

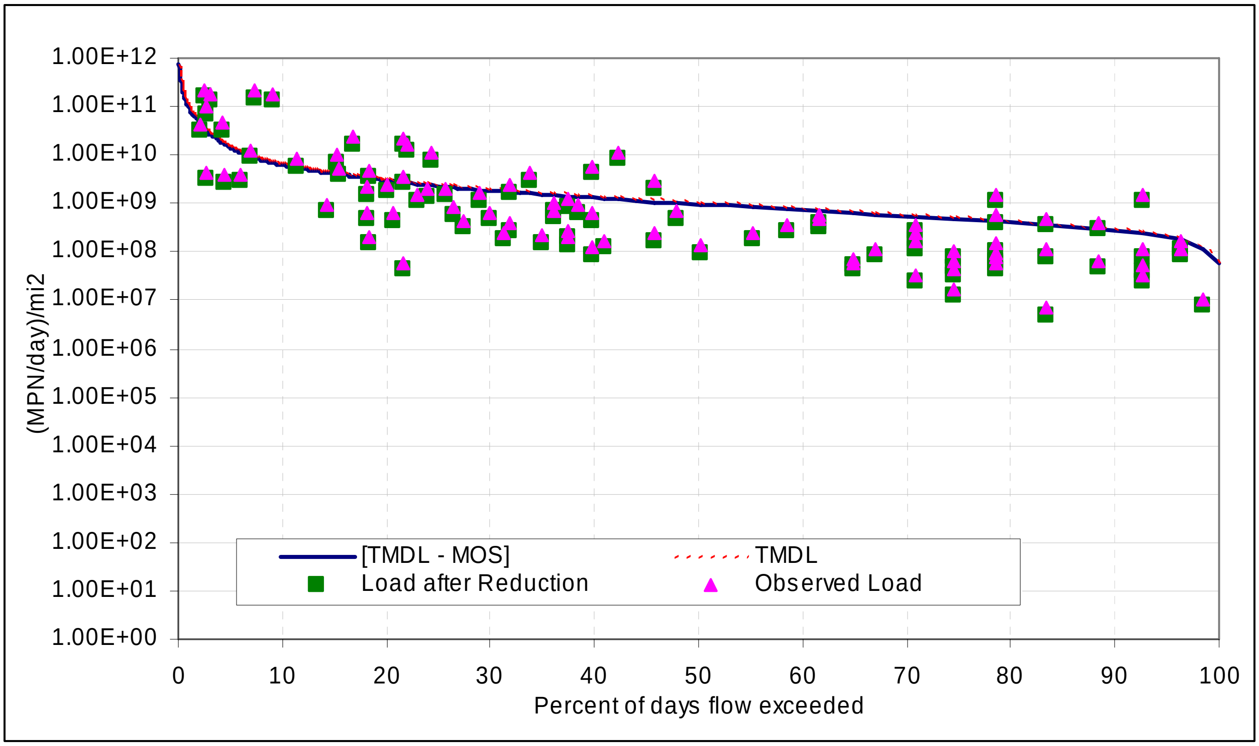

Figure M-9. Summer fecal coliform bacteria load duration curve for Kisatchie Bayou (subsegment 101103) near Lotus, Louisiana (station 42).

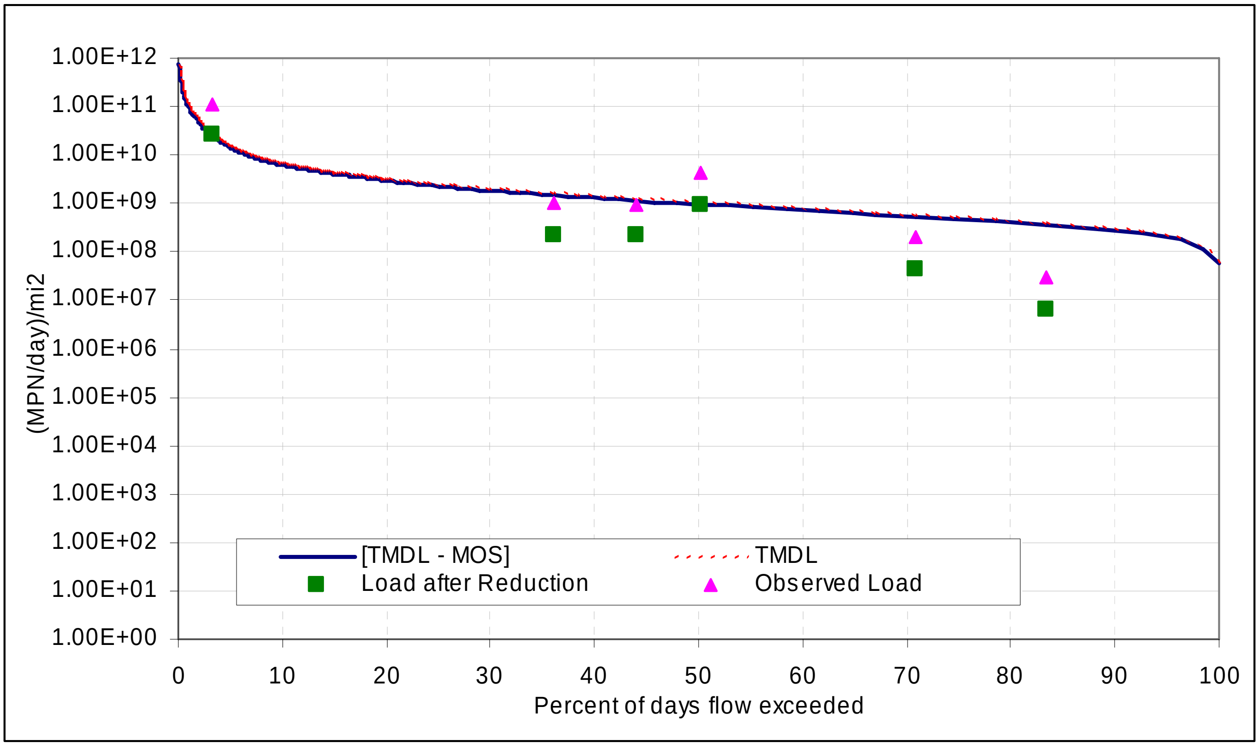

Figure M-10. Summer fecal coliform bacteria load duration curve for Kisatchie Bayou (subsegment 101103) south of Cypress, Louisiana (station 1218).

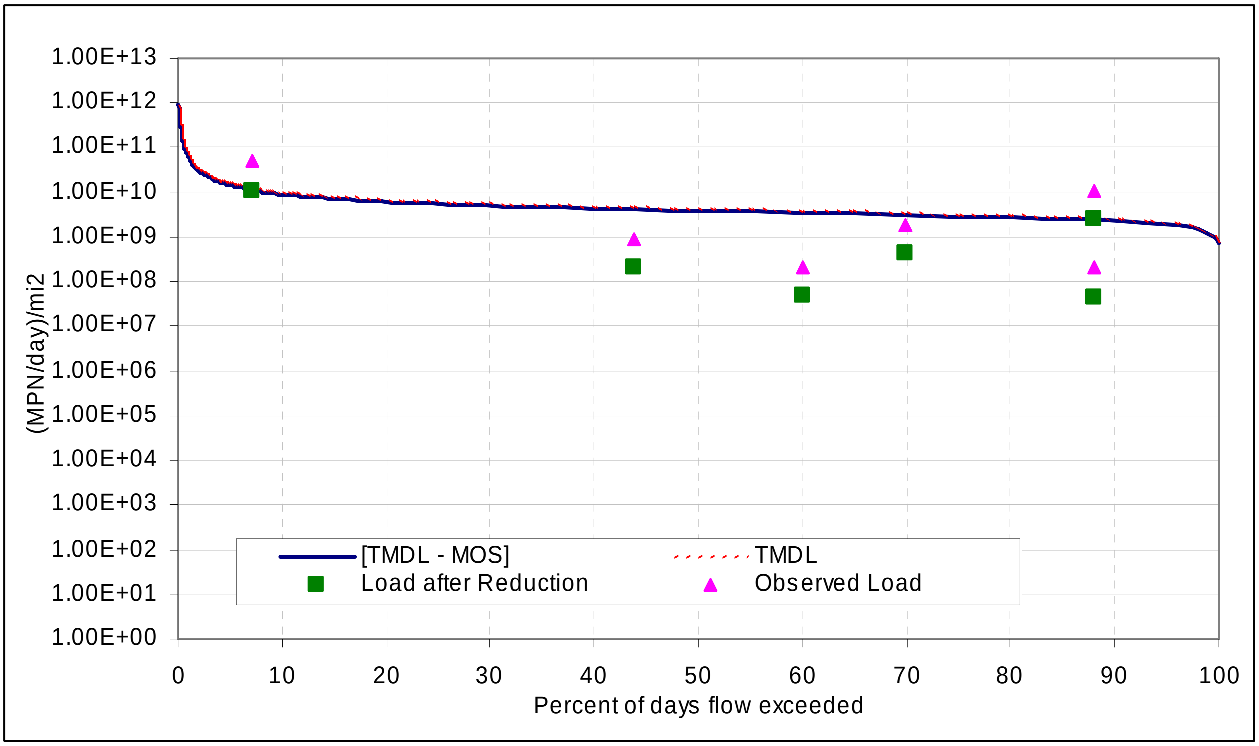

Figure M-11. Summer fecal coliform bacteria load duration curve for Nantachie Creek (subsegment 101301) east of Montgomery, Louisiana (station 1215).

Appendix N
Red River Basin Load Duration Curves and Plots for Fecal Coliform Bacteria: Winter

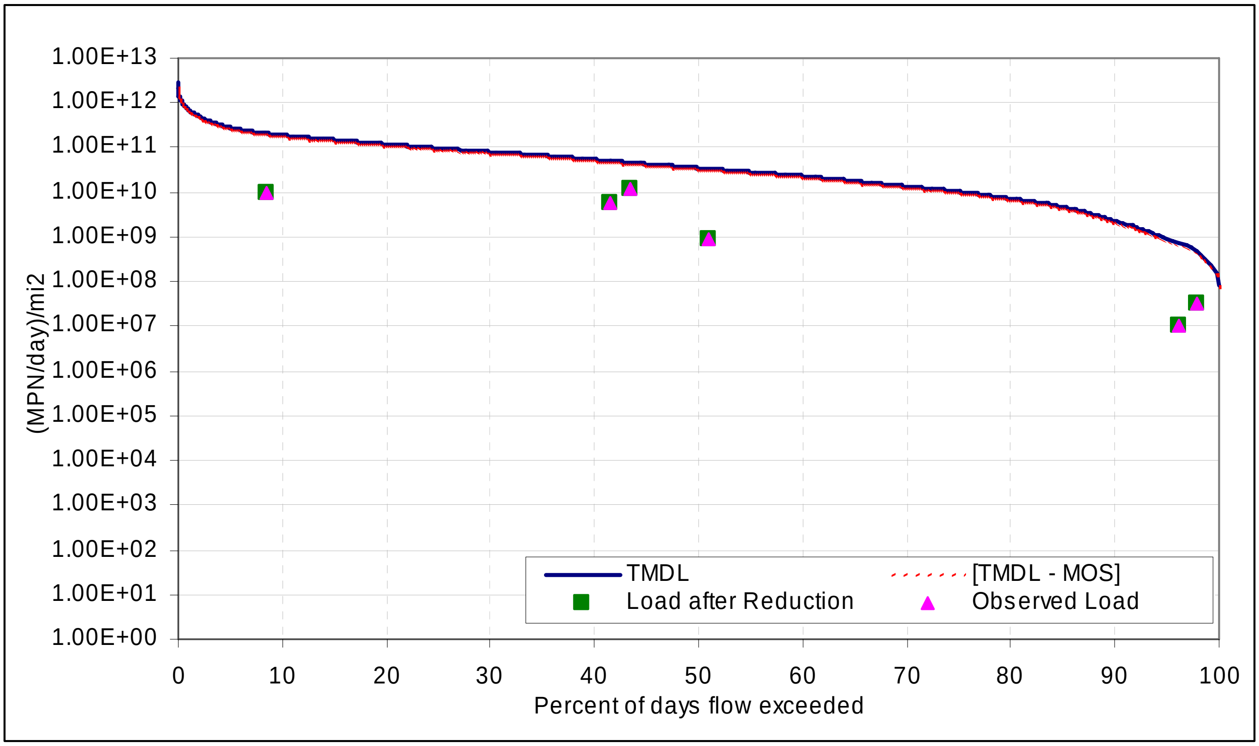

Figure N-1. Winter fecal coliform bacteria load duration curve for Kelly Bayou (subsegment 100306) at Huckaby Road, south of Hosston, Louisiana (station 1192).

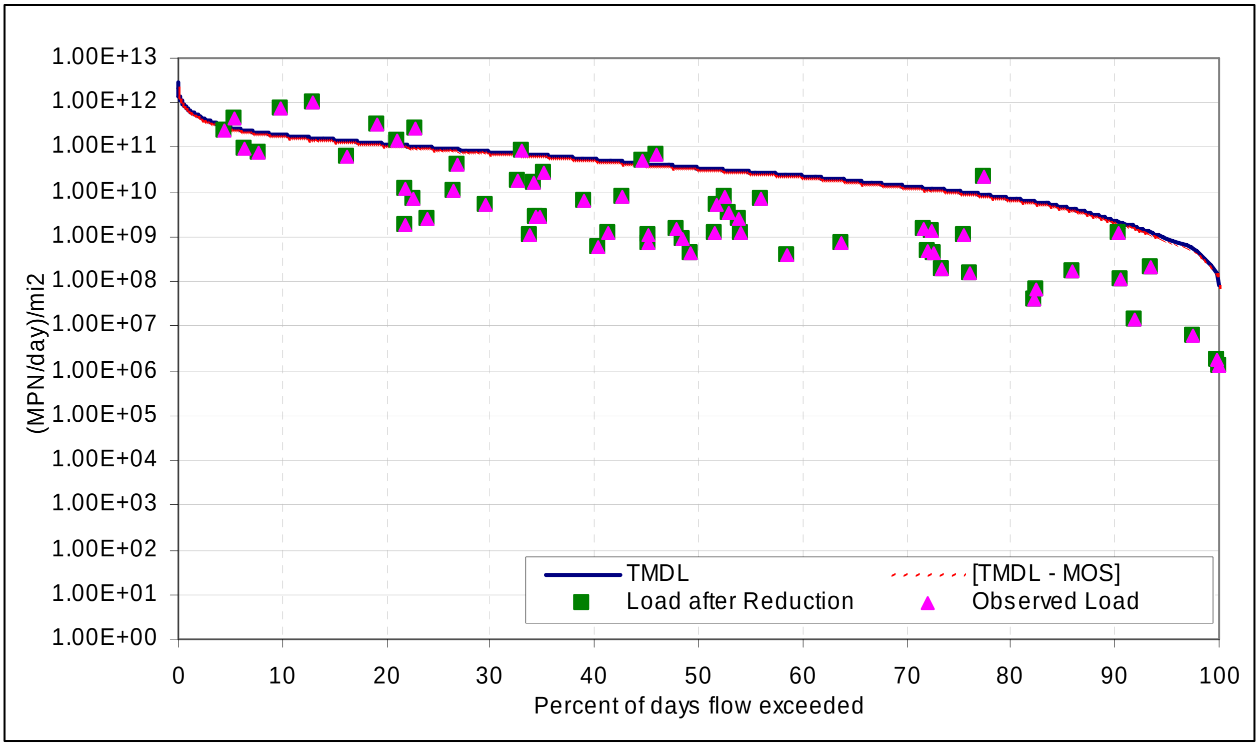

Figure N-2. Winter fecal coliform bacteria load duration curve for Kelly Bayou (subsegment 100306) near Hosston, Louisiana (station 56).

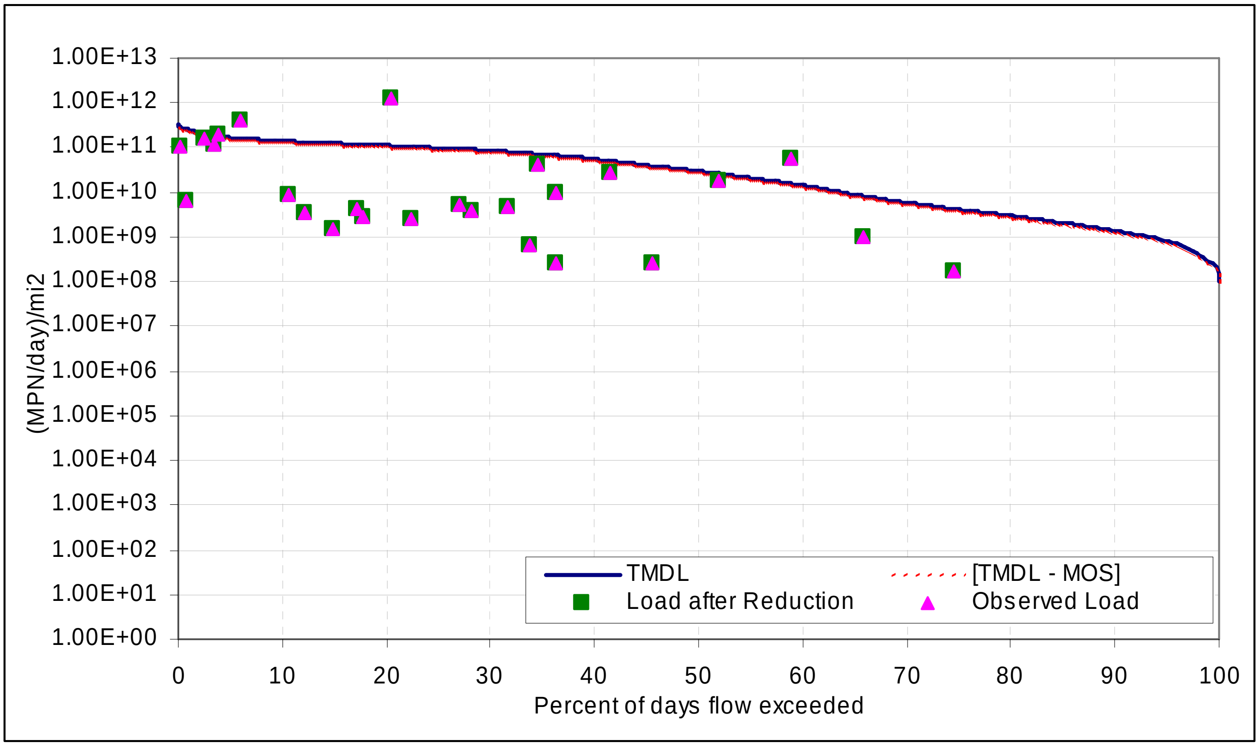

Figure N-3. Winter fecal coliform bacteria load duration curve for Flat River (subsegment 100406) east of Taylortown, Louisiana (station 272).

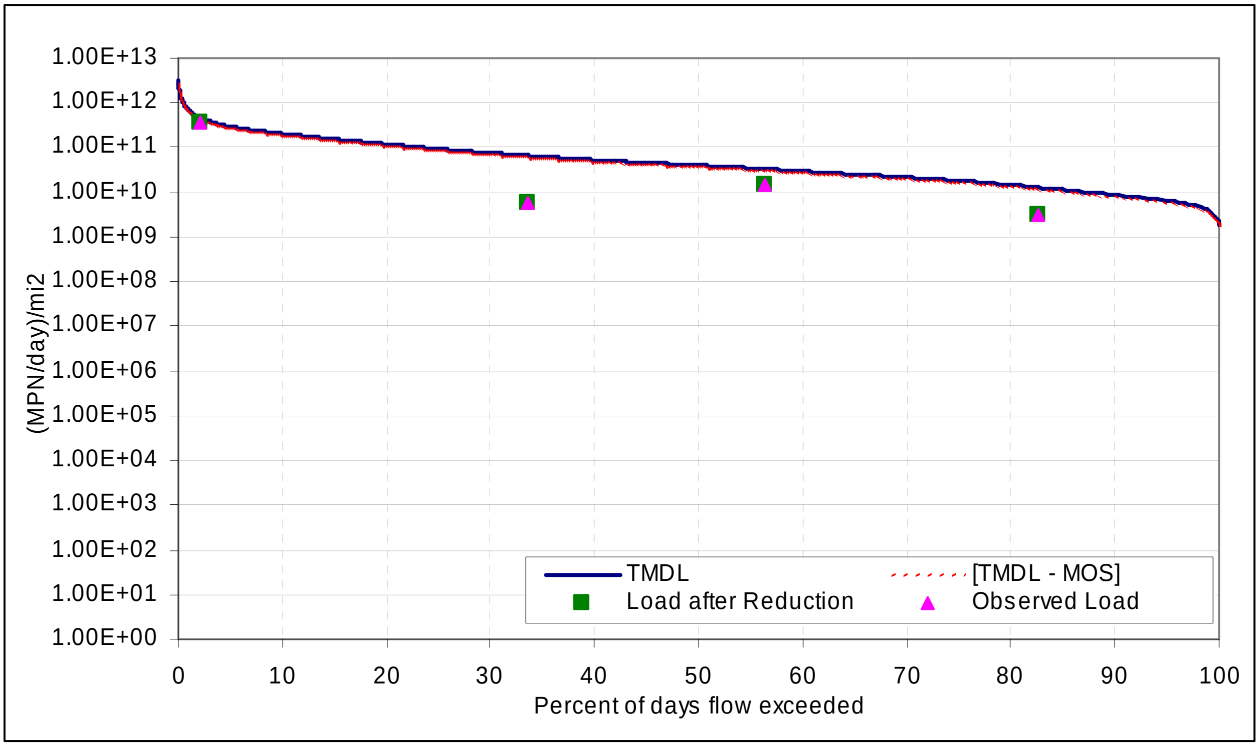

Figure N-4. Winter fecal coliform bacteria load duration curve for Castor Creek (subsegment 100707) at Highway 507, southwest of Castor, Louisiana (station 1189).

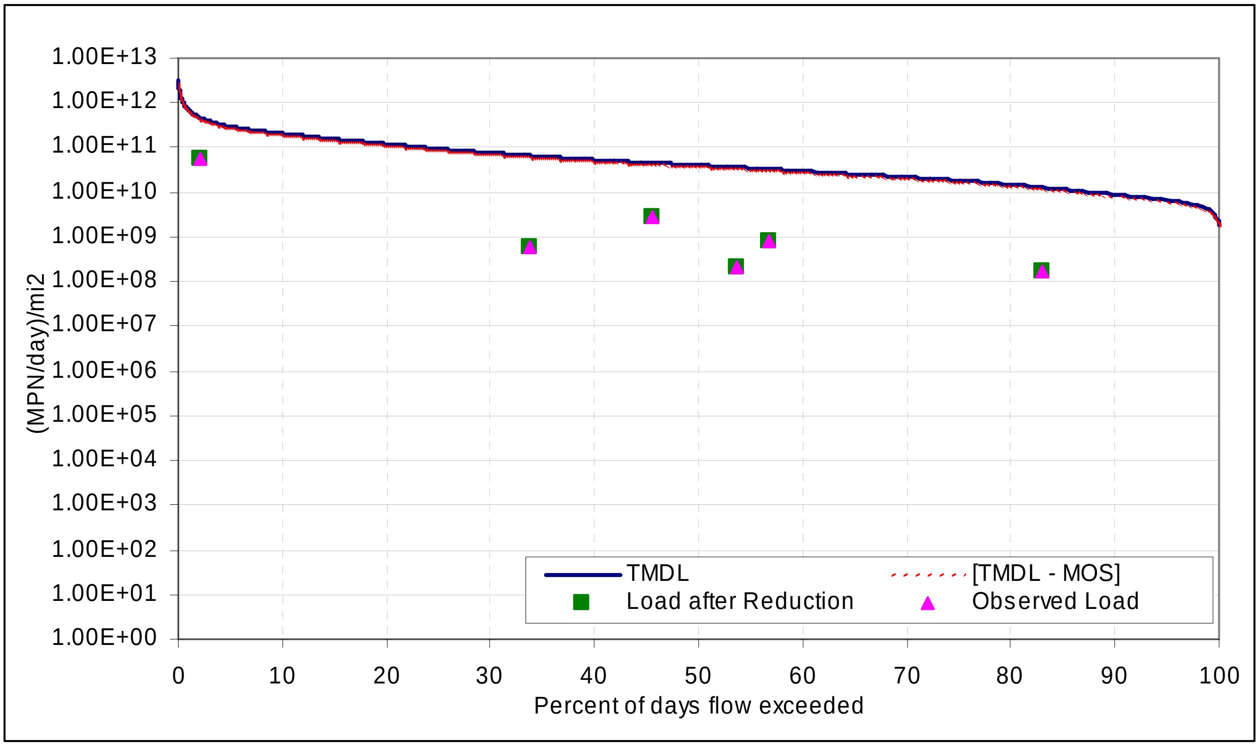

Figure N-5. Winter fecal coliform bacteria load duration curve for Grand Bayou (subsegment 100709) at Highway 507, north of Fairview Alpha, Louisiana (station 1190).

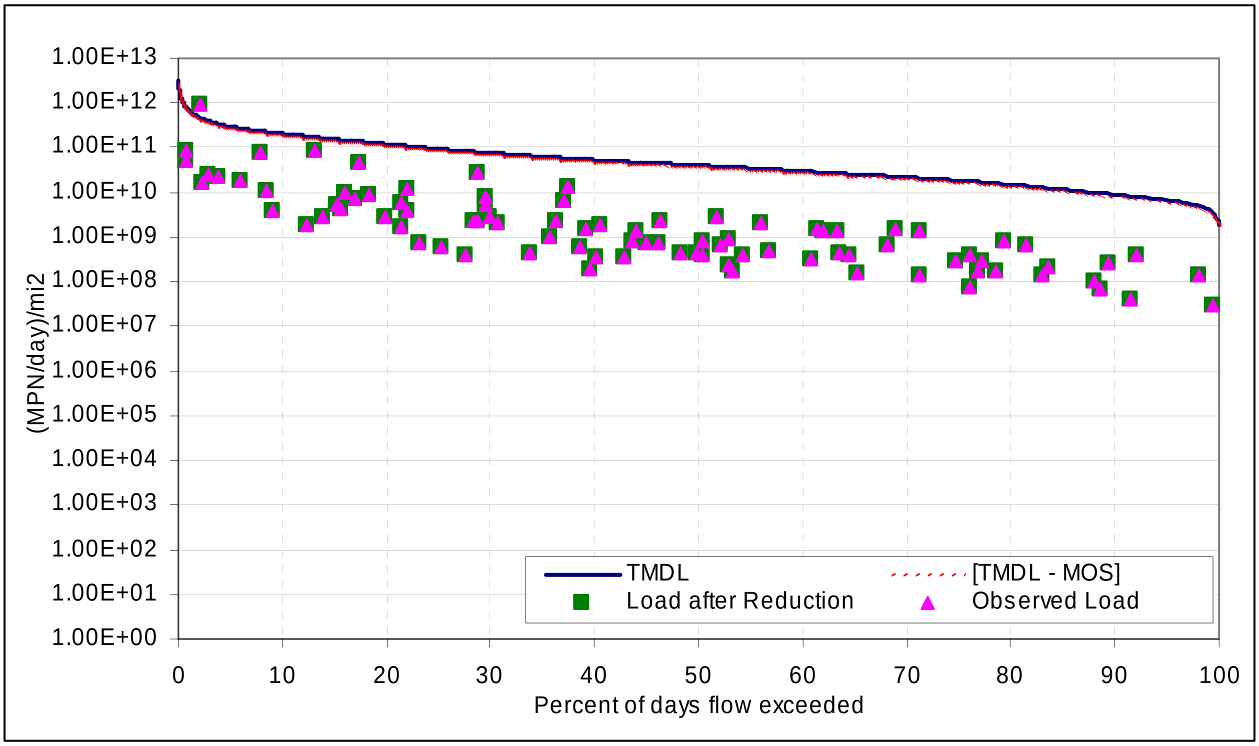

Figure N-6. Winter fecal coliform bacteria load duration curve for Saline Bayou (subsegment 100801) near Goldonna, Louisiana (station 75).

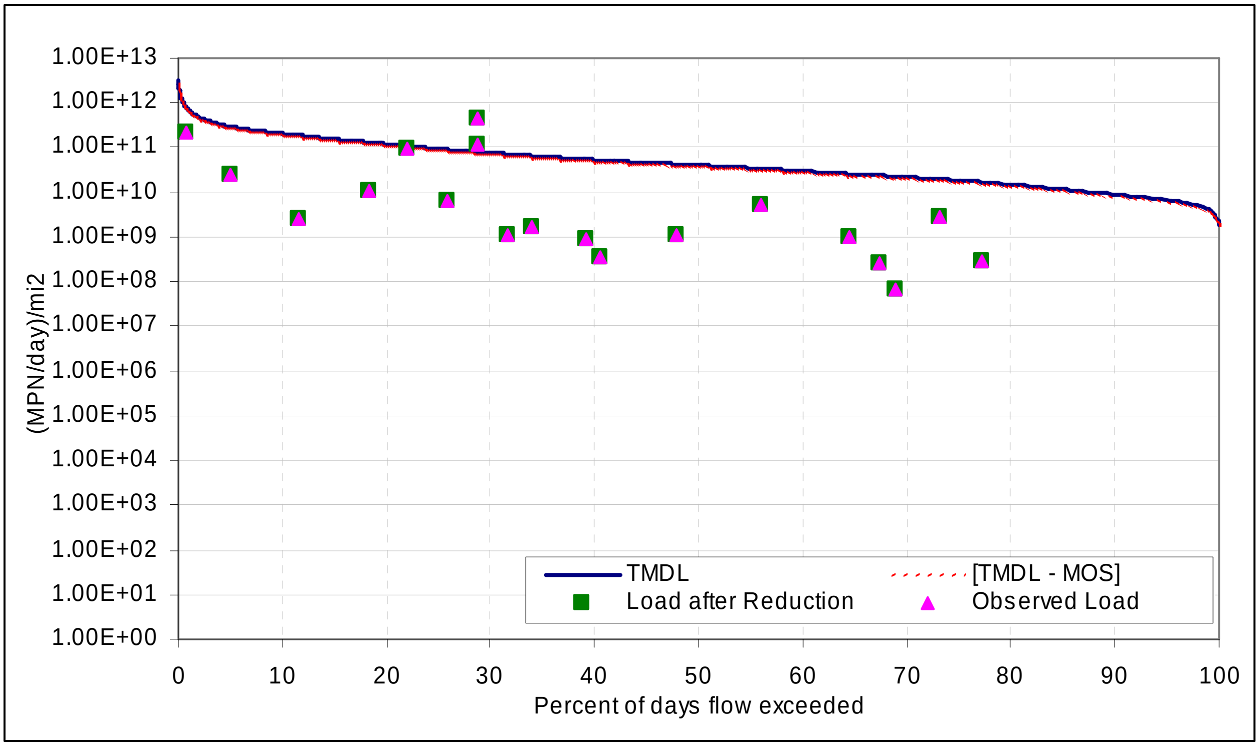

Figure N-7. Winter fecal coliform bacteria load duration curve for Saline Bayou (subsegment 100801) east of Bienville, Louisiana (station 284).

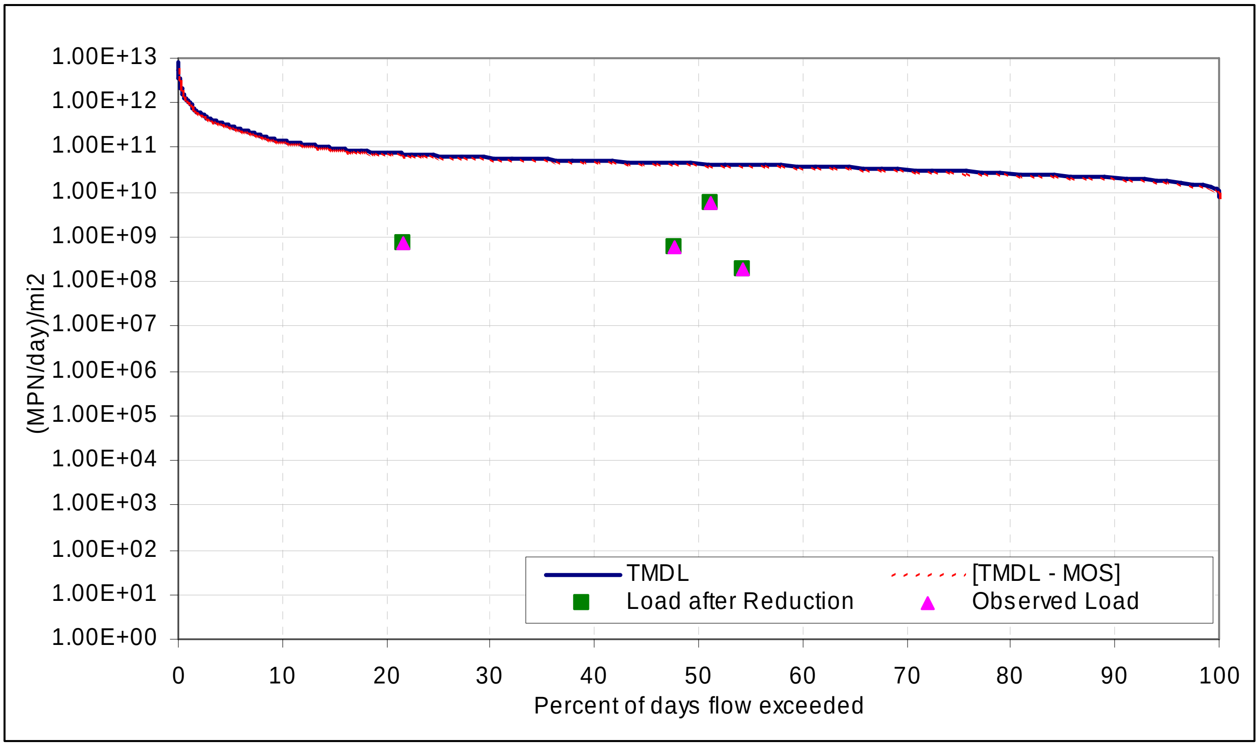

Figure N-8. Winter fecal coliform bacteria load duration curve for Rigolette Bayou (subsegment 100901) northwest of Pineville, Louisiana (station 1220).

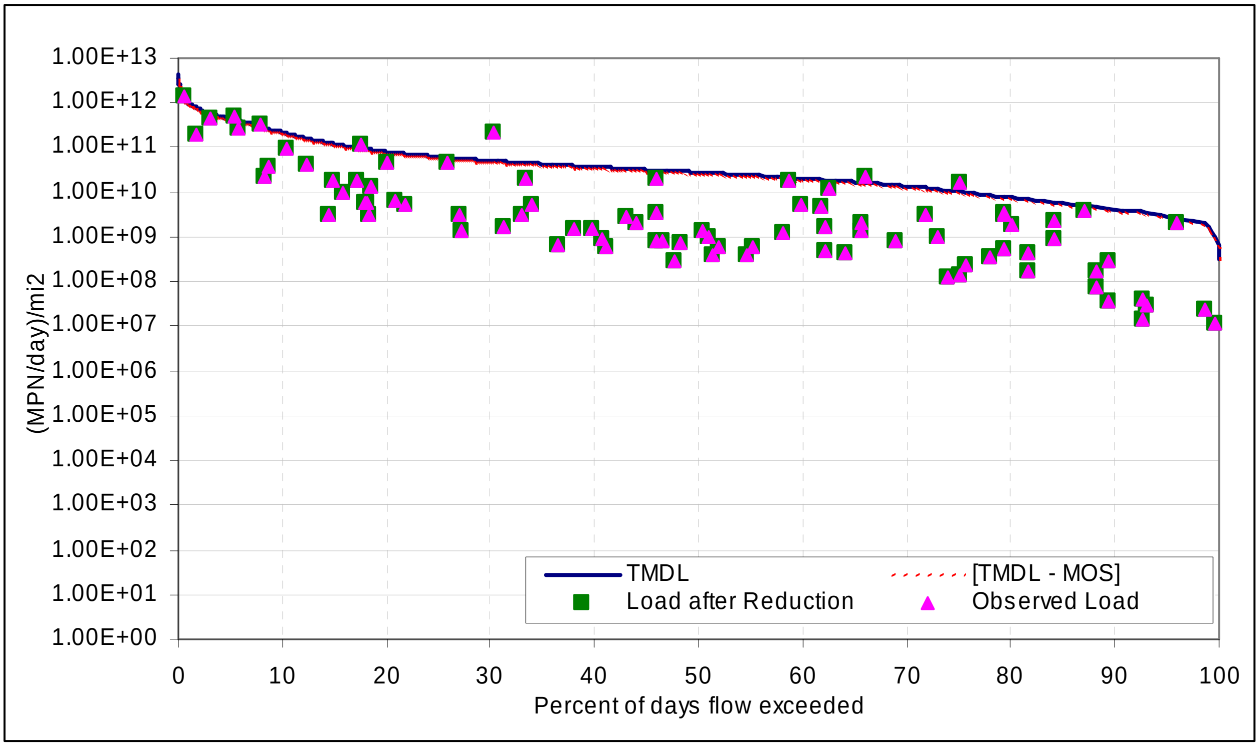

Figure N-9. Winter fecal coliform bacteria load duration curve for Kisatchie Bayou (subsegment 101103) near Lotus, Louisiana (station 42).

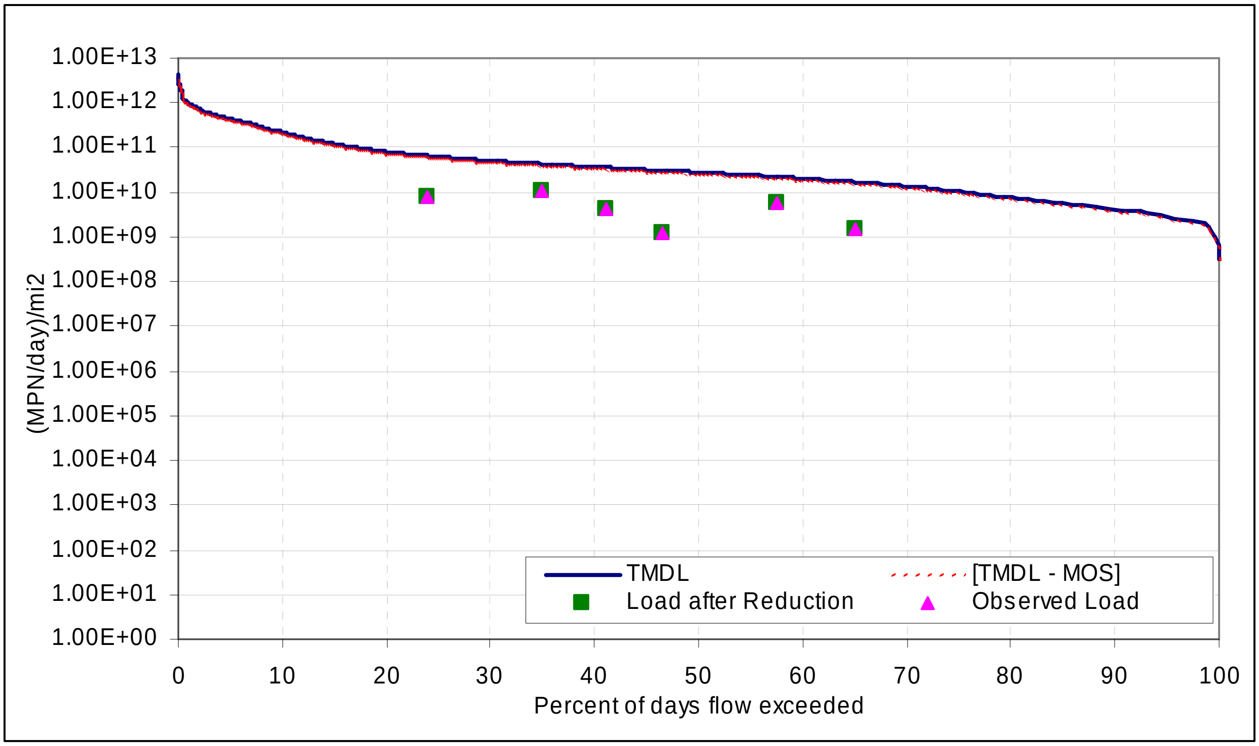

Figure N-10. Winter fecal coliform bacteria load duration curve for Kisatchie Bayou (subsegment 101103) south of Cypress, Louisiana (station 1218).

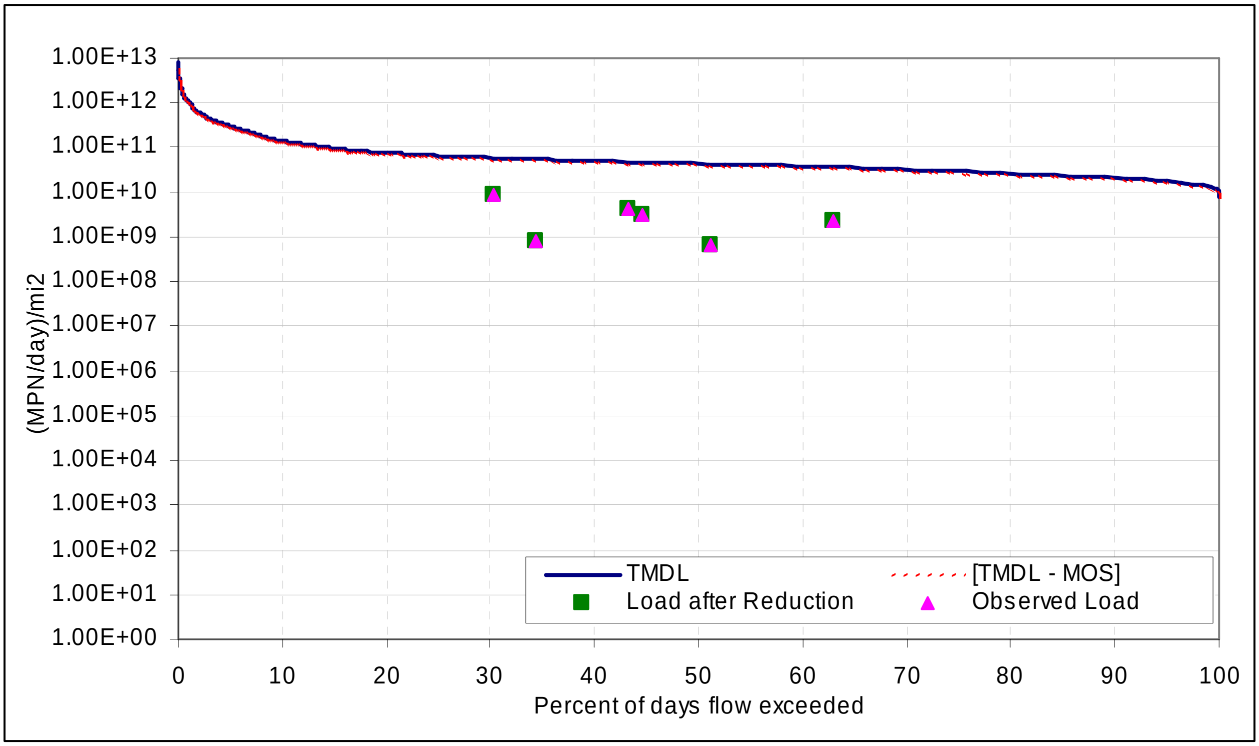

Figure N-11. Winter fecal coliform bacteria load duration curve for Nantachie Creek (subsegment 101301) east of Montgomery, Louisiana (station 1215).